Essential Knowledge for All


Knowledge itself is Power – Francis Bacon

Essential Knowledge for All

A MODERN AND AUTHORITATIVE OUTLINE
OF THE ESSENTIAL BRANCHES OF
KNOWLEDGE FOR ALL WHO
SEEK TO BE WELL
INFORMED

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CHAPTER 1

THE PATTERN OF KNOWLEDGE

The structure of a book. Facts and theories. The texture of knowledge. Evolution of present-day knowledge. Special features of the periods. The framework of the pattern. Subdivisions. The complete picture. Conclusion.

To pick up an encyclopædia, and to study it at random, is to be overwhelmed by the vastness and the depth of knowledge that has been collected within its covers. To prevent oneself from being lost in such a maze one must appreciate that there is a pattern or structure in knowledge which helps one to see how one part is related to another.

Consider this book. It has been written by experts in a wide variety of fields, men and women who have made a life-study of the topics on which they have written. These people have been educated at schools and colleges which have been built by the labour of skilled workers, trained in their turn for many years in their special trades. As young men and women these writers were fed, clothed, and housed, by bakers and milkmen, tailors and garment workers, builders and architects, ploughmen and cowmen, bootmakers, cooks and domestic servants. Without their labours this book would never have been written.

Examine the paper, the binding; think of the compositors, the men who made the type, the men who mixed the metals, the operatives at the printing machines, the designers of these machines, the engineers who assembled them, the mechanics who made the parts, those who tend them and keep them in running order, and again those who taught these men and women their trades and professions. Think of the printing inks, the oils and dyes and other chemicals that have been combined to produce just these inks, the tests and experiments that have been carried through for many years before precisely the right quality of ink and paper could be produced. Imagine the special technical knowledge that had to be discovered, the experience that had to be won before books of this nature could be produced in sufficient quantity to satisfy the demand. This book with its revelation of knowledge was not produced by the writers alone whose names it bears, but by a vast multitude of hands and brains (see Fig. 1). The whole community has played its part in its production. It is a communal, a social effort. It is a revelation not only of knowledge but of the technical capacity of present-day society. Human labour, skill and knowledge from the four corners of the Earth are brought to focus in it.

In a sense this book is not even written today. It represents the sum of the skill, knowledge, and experience of past generations: for what we can do or write today has been made possible by the labours of those who came before us. Out of their experience has come our knowledge—it is our inheritance

from those who have already lived. We stand at the highest point of development of the past. We embody within ourselves in our minds and in our habits, in our traditions and in our books, all that has gone before. Unless, therefore, we can see history as something that grows and develops and to which we all contribute, history becomes meaningless. The growth of knowledge is therefore one of the ways in which history unfolds itself. So it is with all other forms of human activity. So it is with science, with music, with literature, with industry. Each links with the past and leads towards the future. Each has been fashioned by the hands, the brains and the feelings of countless people who have preceded us, and of the multitude of people who maintain social life in all its complexity today.

Background of Society

This book, therefore, is an historic document that not only reflects the past, but mirrors the present also. If, in the near future, our civilization were destroyed by atomic bombs, and if, of all our vast libraries, this book alone survived, tens of thousands of years after this when Man once again had laboriously built up a new way of life it would be possible to reconstruct in imagination the greater part of the civilization of today by a study, not only of the contents of this book, but of the actual materials from which it is made. For behind it stands the whole background of modern society. It is a document for a social museum, because from an examination of its form and make-up can be deduced the technical level of society today.

This book separates the field of knowledge into a series of special subjects. Knowledge is a totality that has emerged by the united effort of mankind. There is a oneness or unity about it. Each generation learns its particular lesson from its own experience, just as each individual does. He works, thinks, feels—and what he learns he passes on to his children, and his neighbours. It drops into the common pool, becomes a tradition in the household, in the family, in the workshop, the factory or the office. It finds its way into conversation, into letters, into books, into schools and colleges. It spreads outwards through the community like ripples on the surface of water. Each generation inherits the best of past experience. Each generation climbs on to the shoulders of the last, and looking back can survey with clearer vision what has been accomplished. The child becomes cleverer than the father, although he may not have his special gifts, for he inherits a richer stock of knowledge; he can look back upon a longer stretch of history.

Facts and Theories

Understanding is not gained by thought alone. It is also a practical affair. We do things, we try ideas out, we ponder over the results, we draw conclusions and we try again. Theories are made to describe, to explain, or to justify what has been done, and these theories are then tried out again in practice. In that sense life is an experiment carried through by individuals in a community; or it may be carried out by the community itself. Knowledge is fact and theory about the world around us—including facts and theories about ourselves—and this knowledge is applied in the practice of living. Frequently

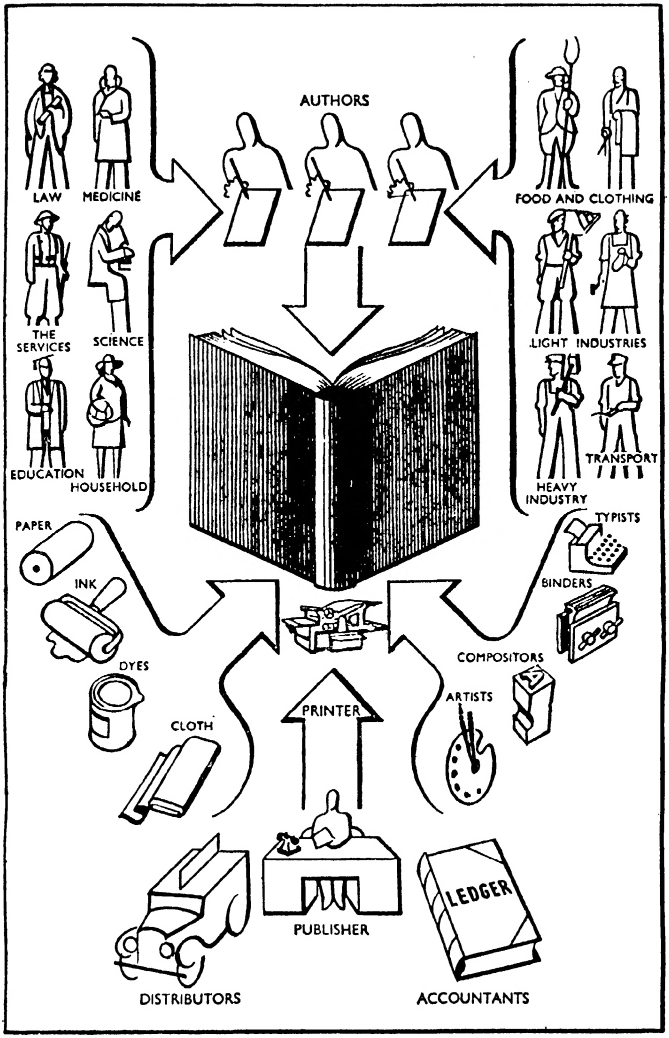


Fig. 1. *Diagram showing that a book is not the product of the writers alone whose names it bears, but of a vast number of skilled hands and brains. Even the paper, cloth, ink, type and blocks, and the printing and binding machinery are the products of research by specialist men and women.*

people are not very conscious of all this, but they act and think more clearly when they are alive to what they are doing.

A time comes in the history of men when they seek to straighten out their knowledge in a systematic way. They take the closely woven cloth, which is the sum of their understanding, and begin to pull the threads apart, to discover the texture. They unpick the strands and follow each as a thing in itself, they unravel the pattern so that the way in which various parts of knowledge fit together may become apparent. For the whole body of knowledge is a going concern which is needed in living. As in a watch, each cog interlocks with another. One part cannot function without its neighbour.

Without general knowledge Man could not carry on. Only after that is he a specialist. So this book has to be seen at one and the same time, as a body of general knowledge, and as a series of illustrations of the separate strands that have been followed up in special detail within the whole scheme or network. The reader can follow it because he has the general knowledge necessary to live at this period at all.

Primitive Man

Knowledge, therefore, must date back to the earliest stages of conscious living matter on the Earth. In surviving, such beings "learnt from experience," and what they learnt, however inexact at that stage, was knowledge. Try to picture primitive Man, perhaps 500,000 years ago, roughly 15,000 generations back. A crowd consisting of a typical member of each generation could all stand in a small field of half an acre. The earliest would be mere uncivilized brutes (see Fig. 2) who, living in small family groups a prey to fear, insecurity and hunger, dwelling in caves and leafy bowers, fed on fish, birds, insects and roots. Their thinking and feeling could hardly be separated. They thought with their feelings, and felt with their thoughts. With bare hands and claws they fought the wild animals of the forests—but they were cunning, more cunning than the beasts. There were dozens of generations like those primitive creatures.

Progress in Civilization

Many thousands of years after them come the men who discovered how to make fire, then the inventors of the stone and the flint axe, and the hammer. The period of tools had begun and civilization had taken its first leap forward. This meant the beginning of construction even if in its simplest terms. With this came clearer thought, understanding in a more modern sense. Thousands of generations later they are smelting ores, and fashioning metal spears, knives and utensils. Soon come the earliest tillers of the soil and the beginnings of animal domestication. These are less like hunters, less like wandering tribes and more like members of primitive agricultural communities. Their general knowledge is now immense. They have begun to be craftsmen although their minds are still blurred by the traditions of many generations of fear and mysticism. The world is so full of events: thunder, lightning, earthquakes, that are incapable of being understood; events that instil fear of the unknown; elaborate rites and ceremonies have grown up to make peace with these furies of nature,

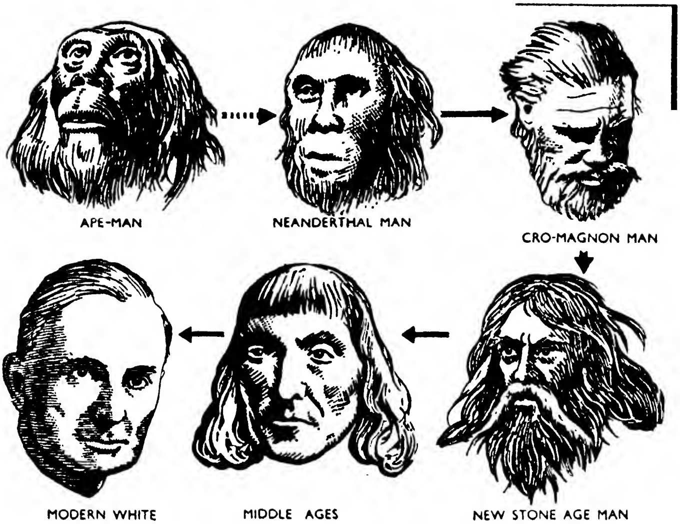


Fig. 2. *Sequence of types which traces the modern white back to the supposed ape-man. Neanderthal and Cro-magnon Man are named after caves in which human bones were found, the Neanderthal cave of the Dussel Valley, Germany, and the Cro-magnon cave of the Dordogne, France.*

and to encourage the peculiar spirits that people their world, to deal kindly with them, to provide them with the rains they need and the crops on which they depend for their survival.

Archæologists who have dug out the sites on which these primitive communities settled have unearthed their axes and their spears, their burial places and the foundations of their dwellings. They have even built up a picture of the social customs of these primitive peoples, their rites and ceremonies, the background of knowledge and technique they had at their disposal, and the manner of their artistic expression. What they knew of minerals and the treatment of metals showed itself in the materials out of which these articles were made. Since those days such subjects—they are specialized branches of knowledge discovered in the effort to satisfy human needs—have now expanded into recognized branches of science—*Mineralogy* and *Metallurgy*.

They had their own special dwelling houses and shrines, too, primitive as they were, in which they used the mud, clay, wood and stones to be found in the environment in which they lived. Precisely the same underlying principles have served since those days to direct the development of that now highly technical subject, *Architecture*; for whether buildings be churches, houses, factories, or educational institutions and museums, the raw

materials (and now also manufactured materials) at the disposal of society, and the purpose of the buildings, serve, along with ideas of beauty and elegance, to determine the principal characteristics in such structures.

In very much the same way, the mystical rites and incantations through which these early men hoped to persuade the gods to provide the necessary rains to fertilize the soil, have now, after thousands of years of experience, evolved into the scientific studies of *Climatology*, *Meteorology* and *Agricultural Science*.

Cultural Expression

Looking back on these primitive communities one can see how the possibilities for their survival depended on a widening of their understanding of nature, and a deepening of their knowledge of how to handle the raw materials which nature provided, and so safeguard themselves against accident and catastrophe. With security so won, came also the possibility of cultural expression—crude as it might be—in song and dance, and in shape and form; the former associated in the first instance with religious and fertility rites, the latter in relation to their idols and their domestic utensils.

As communities grew in size and complexity, language expanded with it, in the effort to express their gathering experience. New practices, new knowledge and new theories implied a growing and more subtle use of words, a greater vocabulary. With the invention of writing, society took a new leap forward, for the act of putting signs or symbols on stone, on clay, or finally on parchment or paper, meant the birth of *Symbolism* to express ideas, thoughts, feelings, facts or information. In this sense it is akin to all other forms of artistic expression which are always symbolic of the things expressed. It meant that an idea or a train of thought could be fixed in time, and re-examined at a later date. The period had begun when men could begin to study their own thoughts objectively by re-reading these marks, just as they could study any other material object in nature. There is little doubt that writing was originally of the nature of picture stories or *Hieroglyphics*, in which the unit was the whole word or even the whole idea, and that the alphabet in which the unit is a small fraction of a word, arose out of the attempt to put together elementary pictures that brought out the sound of the whole word. The relation of one language to another is now a special study—*Linguistics*; while the study of the history of words is called *Philology*. The roots of language in its written form lie ultimately in the need men had for communicating ideas and information by methods other than by word of mouth. Out of this social necessity has grown the vast region of cultural expression which we call generally *Literature* and *Art*.

History of Society

Each period in the history of society, from the earliest of primitive times to our modern industrialized society shows its own special features. The hunting stage; the period of primitive agriculture; the feudal period in which peasant communities were merged together under feudal lords to whom they owed allegiance, and for whom they laboured as serfs; the era of the

Fig. 3. *Sequence of the stages of development, showing how science and art emerge in the struggle of man to control nature and to direct his own destiny. The baronial castle was a typical example of art coupled with the need to maintain feudal power during the Middle Ages.*

craftsman and the merchant who became wealthy by selling the products of the craftsman in distant lands, and so indirectly stimulating navigation and shipbuilding; the entry of the industrialist with his mechanized system of factory production with its consequent outpouring of commodities to the four corners of the Earth; and most recently the emergence of the Soviet Socialist system in which private ownership of industrial machinery has disappeared—all these represent distinct periods in the history of Man (see Fig. 3). The study of the forces that brought these changes into being is called *Sociology*. It includes also the detailed examination of each period. Because all knowledge has grown from the experience of men who have struggled to build a way of life, and in doing so have brought about these vast social changes, it follows that sociology is the most fundamental of all studies. In a sense all other fields of inquiry are subdivisions of sociology.

Modes of Life

Each such period meant a distinctive way of life for those who lived and toiled at that time. Their minds and their feelings were bound up with the problems of their period. Inheriting the knowledge and experience of their forbears, accepting the assumptions on which their own way of life was based, and modifying them as a result of their own limited experience they developed a distinctive outlook on life. To each, the stage of society in which he found himself seemed a permanency. He could not see history as we see it today—an ever-changing process. He tended to accept the recognized viewpoint on what was good and what was bad, what was important and what was not, and where his duty lay. People had common aspirations; they thought about the same things, their minds tended to set in the same mould. They all breathed the same mental atmosphere. All this means that in a very broad sense they had a common philosophy of life—a common *Ideology* as it is called. The study of ideologies can therefore be regarded as a section of the wider study of sociology.

Broad Framework

We are now in a position to set out the broad framework within which the pattern of knowledge must show itself (see Fig. 4). In the course of time each of these subsections has become itself subdivided and specialized. Science, for example, has separated into three broad basic studies (see Fig. 4). The first is concerned with what has emerged out of the various forms of group life through which communities have passed. Thus it includes History and Economics, with such special studies as Economic History, Political Theories, Law, Trade, Commerce, Finance and Production. The second embraces Physics, Mathematics, Chemistry and allied topics. Physics attempts to set out the natural laws that show themselves in the world around us: the Laws of Motion, the Law of Gravitation, the Laws of Energy-change in the form of kinetic energy, heat energy, light energy, electrical energy and even matter itself which is now regarded as a form of energy. Mathematics is a symbolic method for examining what is logically implied in any given set of assumptions, and for tracing out the consequences of the

various natural laws. It is therefore a very fundamental part of scientific theories, expressing them in precise and definite form. The *Science of Man*, the third main subheading on the other hand, is concerned with the place of Man in nature and deals with such topics as the *Theory of Evolution*. It includes also the general subjects of *Zoology* and *Botany*, and their joint study in *Biology*; that is to say, the systematic examination of the structure of plant and animal life, and the relation between them. It includes also a study of the way in which environment and living matter act on each other—*Ecology*.

Borderland Subjects

It will be seen at once that these three main divisions cannot be separate and distinct studies. Not only are they linked together because their study emerges from the activities of man in society, but the general laws of the material world as detailed under the second heading apply also to living matter. Thus there are borderland subjects such as *Biochemistry*, that is the chemistry of living matter. Again, the study of *Mathematics* includes such a subject as *Statistics*, the mathematical analysis of groups, and this finds its expression in social and economic problems and in the examination of the varieties of animal life for they also occur in groups. Moreover, one of the most fertile studies in relation to inheritance from one generation to another, *Genetics*, as it is called, is on the theoretical side at any rate almost a purely mathematical subject. Again in *Histology* that deals with the structure of cells in animal life, *Cytology*, and other subdivided studies of living matter, the apparatus that is used has come into being as a result of advances in the physical sciences, and so for their interpretation, principles drawn from experience in physics are now invariably employed.

Finally, society after all exists in a material world, and is conditioned and changed by it. Man exists in society and is in his turn changed and conditioned by that social environment. Thus the subject matter of the first subdivision, viz. *Science of Society*, is conditioned by the subject matter of the second, viz. *Science of the Material World*, while the subject matter of the third, viz. *Science of Man*, is conditioned by the remaining two. It is in this sense that attempts to separate a united body of knowledge into distinct sections must, in some respects, falsify the picture.

Science of Society

So far, the first main subdivision of the Science of Society is concerned with the technical and scientific aspect of social life. When we turn to the second of these three main subheadings : *Cultural Practice* and the theories associated with it, we are drawn away from those pursuits that are principally intellectual to those that appeal first to the emotions and feelings—Music, Drama, Dancing, Pictorial Art, Sculpture—partly also Architecture—Literature in prose, and in poetic form, the Cinema. In this field enter also the various techniques of expression that make use of scientific discovery in colour, lighting, materials; and the principles on which judgments of value are based, viz. Aesthetics. On such a topic much knowledge is gained by a study of the historical evolution of each of these aspects of social and individual

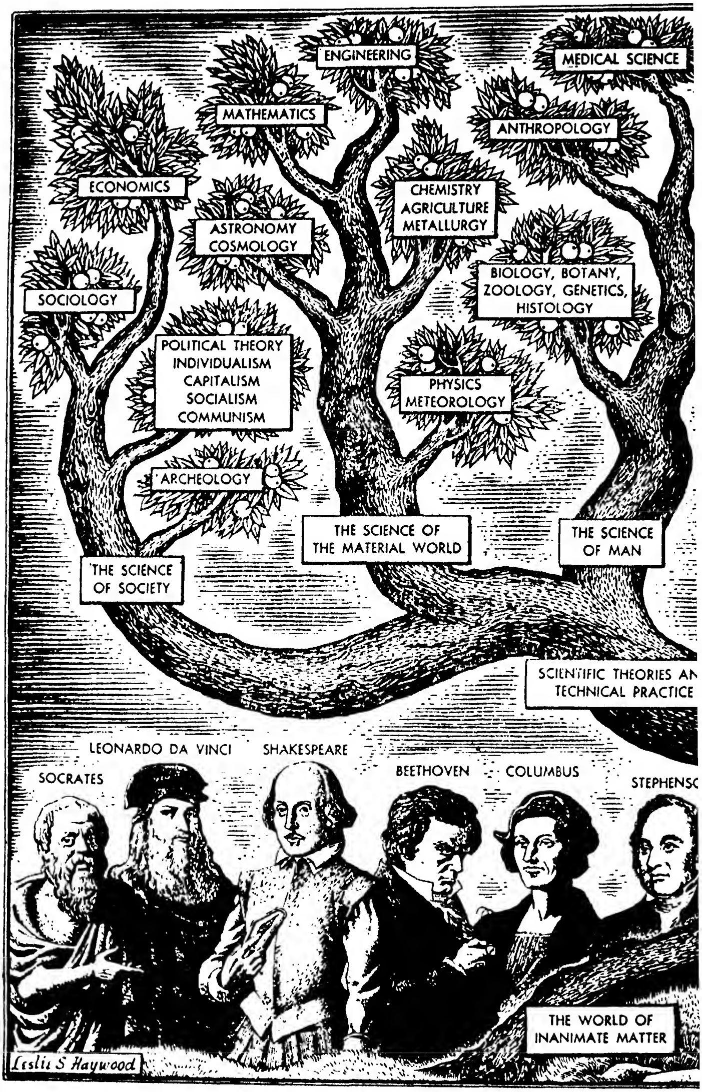
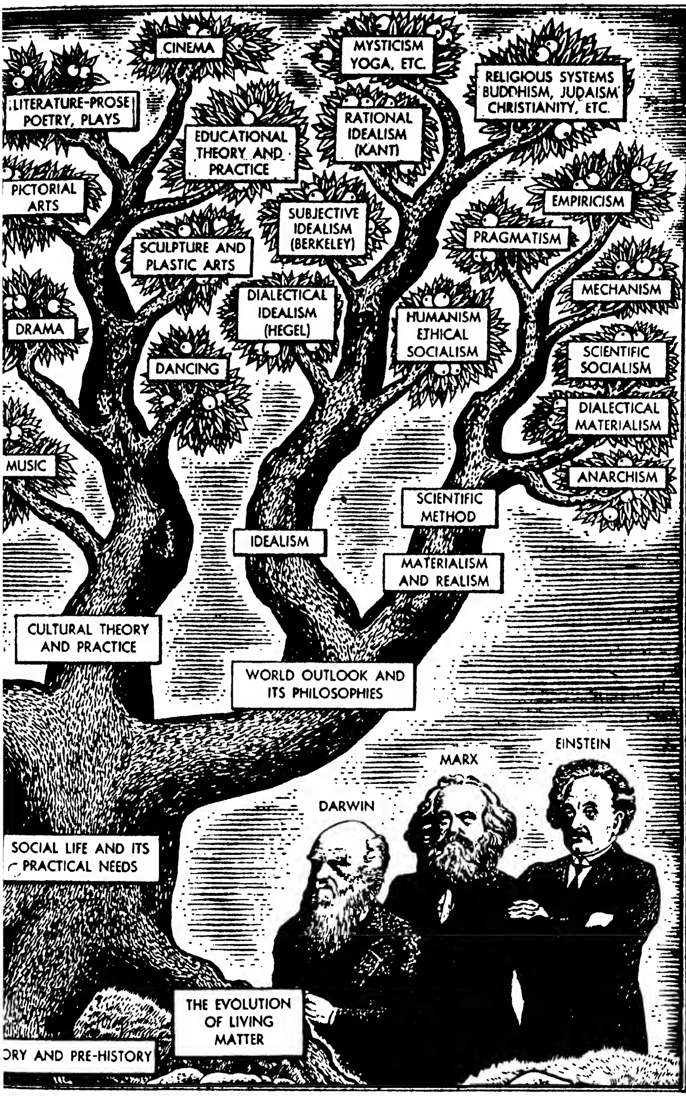


Fig. 4. *Diagram showing how the pattern of knowledge can be likened to the branches of a tree, with its roots deep in history and pre-history,*



inanimate matter and the evolution of living things. The men in the foreground have each made outstanding contributions to a specific subject.

expression. In this sense this subsection links up with the *Science of Society* within which history, in all its aspects, must also fall. Thus the table for the third main heading takes its form (see Fig. 4).

Again these are not distinct. Two or more of these art forms may be linked together, as with music and dancing for example. Moreover, each of these has a special history of its own which reflects the social purpose of these branches of art at different stages of society. Hence, while it is true that the artist expresses himself as an individual in the work which he creates, he does nevertheless speak or write for his period, and deals with topics that are understood and have meaning for his contemporaries. In that sense art links up very closely with sociology. Moreover, the medium which is used leans heavily on the technical materials that have been developed and invented at any stage.

The art of the cinema could not come into being until the technical and scientific problems of moving pictures had been solved. Instrumental music could not pass from the primitive stage until the piano, the organ, brass instruments, the flute, the oboe, etc., had been developed. It is not difficult to see why all of these professions were unable to expand to their present proportions until the age of commercialism had come. When music was under the patronage of the church or of wealthy members of royal courts one class of music was encouraged. When business enterprise seized on it as a source of profit a new level of popularization developed as with jazz. In this way it becomes clear how the background of social life conditions or tends to direct certain aspects of the course of artistic development. Finally, *Education* covers the whole of this in the sense that it is concerned with the problem, in theory and in practice, of bringing it to the understanding and appreciation of young people at schools and colleges, and to older people through the radio, etc.

Now the study of *Aesthetics* which seeks for tests to help decide what is and what is not good art, and the nature of artistic taste, links up with one's philosophic attitude, and this itself falls into the heading *World Outlook and its Philosophies.*

World Outlook

A philosophy is an approach to the world around us, an outlook that helps us to piece together the wide variety of experiences we have, that helps us to decide what is and what is not important and so guides us in our judgments and actions. Whether one is conscious of it or not, one's actions reflect such a philosophy.

Now it has already been pointed out how each period in history —including the present—possesses a certain mental and emotional atmosphere of its own, and so it is not surprising that the ideology of each period has been expressed in special philosophies. These fall broadly into two classes. There are the realistic or materialistic philosophies that seek an explanation and an understanding of the things, ideas, feelings and moral judgments of this world, in terms of tangible or verifiable things of this world. No appeal is made to anything outside that realm. In fact, by existence is implied only the features of this world. The other school can be broadly classed as *Idealist* in which truth and reality is conceived

of as not restricted to matters verifiable. The universe is considered to be mental or moral or spiritual in nature, and the world we touch through our senses is regarded as derived from this. There is, for example, the philosophy of *Mysticism*, in which by various devices one seeks to grasp spiritual truths that are supposed to lie beyond direct understanding.

There are philosophies of *Humanism* in which devotion to human interests as opposed to spiritual interests are of primary concern, so it is considered that if steps are taken to build up a moral world, it will automatically work out right in practice.

This view that moral questions are primary is shared also by the various theological systems that have been proposed—Buddhism, Judaism, Christianity, Mohammedanism, etc.—with varying degrees of stress on the importance of the supposed reality of a world other than that of the senses. Finally, there is the completely *Subjective Idealism* that asserts that the underlying reality is purely mental, and that the materiality of the world as we seem to sense it is only apparent.

Economic Practices

Philosophies, as has been stated, have emerged at various stages in the development of social life, and therefore to that extent at least are sociological. Side by side with these, and in certain ways indistinguishable from philosophies are the various justifications that have been advanced for the continuance or the creation of one or other form of social system. *Individualism*, *Capitalism*, *Anarchism*, *Socialism*, *Communism*, each in its own way seeks to show that if the methods of production and distribution of the basic needs in a community are organized in accordance with its principles then a situation will develop in which the moral and cultural aspirations of human beings will be satisfied. These, the theory of certain economic practices, are at the same time social philosophies. They have therefore to find a place both under the present heading of *Philosophy* and under that of the *Science of Society*. The picture, therefore, can now be completed (see Fig. 4).

Conclusion

In conclusion it is important to bear in mind the general principle that each of these separate subjects borrows or depends on the general body of knowledge gathered throughout the ages by Man in his struggle with nature. Nor are the separate categories distinct from each other. For example, materialism of the mechanical sort, which regards the universe as a vast machine (which dialectical materialism does not) in which everything is in principle predictable would seem to imply the existence of a Great Engineer responsible for the running of the cosmic machine—apparently therefore bringing it finally into the category of an idealistic or a mystical philosophy. Again Individualism carried through to its logical conclusion has much in common with Anarchism. Some humanists would regard themselves as materialists rather than idealists. The whole pattern or scheme which we have developed is in fact tentative, and to be regarded more in the light of a theory of the structure of knowledge and therefore as a guide to study than as anything that is firmly and finally established.

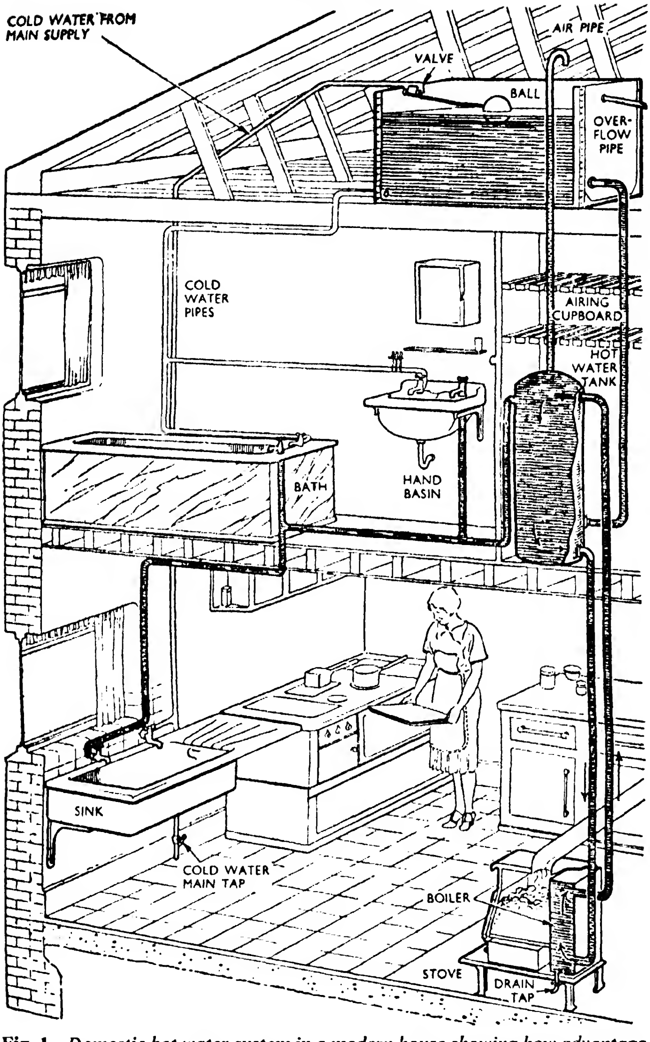


Fig. 1. *Domestic hot water system in a modern house showing how advantage is taken of convection currents (see page 44) to circulate the heated water in the boiler and in the hot water tank. The direction of the convection currents are indicated by arrows alongside of the pipes and in the tanks.*

CHAPTER 2

THE SCIENCE OF INANIMATE MATTER

What science does. Laws of motion. Forces and acceleration. Measuring acceleration. Work and energy. Matter. Molecules and atoms. Energy. Size of the atom. The chemical elements. Chemical combination. Chemical compounds. Compounds of metals. Compounds of non-metals. Organic compounds. Heat. How heat travels. Solids, liquids and gases. Change of state. Steam as a source of power. Electricity and magnetism. Electricity. Magnets and electricity. Telegraphs and telephones. Sound and the telephone. The dynamo, motor and transformer. Transmitting current. Radiation. Electromagnetic radiations. The making of light. Electric lamps. How light travels. Reflection of light. Refraction. Optical instruments. The camera and the human eye. Microscope and telescope. Colour. The spectroscope. What the eye sees. Invisible rays. Short waves.

THE world which we perceive seems to be full of things; some of these we recognize as being alive like ourselves, as having the power of maintaining themselves recognizably the same through a process of continual change and reaction to a changing world, as multiplying themselves and so increasing their number, and as having some of the other qualities we associate with life. Other things have not such qualities and these we call inanimate.

Even so, however, living things have many of the properties of the non-living, for like these they are made of matter in motion. A man and a motor car both burn fuel and thus make energy, which appears as heat and work; and the same laws concerning heat and work apply to the man and the motor car. So almost all that this chapter contains is also applicable to living things; but as the most interesting and important ways in which these behave are not found in the non-living, they are studied in Chapter 4. The science of inanimate matter, therefore, consists of a scientific study of the properties and behaviour of all non-living things.

We are to study things by science, but this is not the only way to study them. The scientist sees a rock as a mass of, it may be, calcium carbonate formed by a myriad animalcules 100 million years ago, and carved and shaped by geological forces into its present shape; the painter sees it as a pattern of beauty; the poet as an emblem of endurance in adversity. All three are true visions, and the scientist's does not exclude those of the painter and poet.

So the raw material of science is Man's perceptions, all that he apprehends through his senses; but of that material the scientist uses but a small part—the part that can be set down in terms of number, weight and measure. Anyone who looks into a book of physics will be at once aware that science works in

that which can be specified by numbers—sizes, shapes, weights, velocities and so forth—yet not only physics, but also chemistry and even biology, are really concerned with these measurable aspects of things, though the manner of their expression may cover it up.

Length, Time and Mass

Science, then, studies the world in terms of measurement. It talks about size, shape, force, speed, hardness, temperature, and so on, and all these can be expressed in terms of measurements of length, time, and quantity of matter (mass). Thus speed (velocity) is the *length* moved in a given *time*. Force is that which causes a given increase of *speed* in a given *time* to a given *quantity* of matter; and so with all the scientific units. Whatever the scientist says comes down to measurements of length, time and mass, and science can talk about nothing else. So if anyone tells you that science says that something *ought* to be done, that something is good, right, honourable—disbelieve him. You cannot start with lengths and masses and times, and argue to honour or beauty, but of course ideas of honour and beauty may be affected by the knowledge science provides.

Science has three chief aims : to describe things exactly; to explain the unfamiliar in terms of the familiar; and to enable Man to alter his world—for better or worse as he chooses. The first two aims are those of pure science, the third is that of applied science—which is pure science applied to Man's use.

The descriptions that are made by science are intended to be exact and completely intelligible. If I say that salt gives a yellow colour to a gas *flame, I say what anyone can understand, but it is not exact. There are many different yellows and different people seem to see them differently.* But if I say that such a flame gives out light of which the wavelength (page 64) is 0·0005893 millimetre, then I am giving a description which is exact because it states a length in numbers, although to those untrained in science it seems much less clear than the word "yellow." So science tries to put everything in numbers, and the more exact the figures and the fewer the words the better the science.

How is it that science can put so much in numbers? Chiefly because science supposes that everything that science studies consists of waves or particles in motion and so, if we could state the masses and forces and velocities concerned, we could state all that science (as distinguished from art, philosophy or religion) could say about anything; we could explain the material world in terms of science.

Scientific Explanation

If you ask a man to explain a typewriter he will say: "Press down this key, then that lever will push against this lever and release this spring," and so forth. That is the kind of explanation science wants, and it is the kind of explanation it can give of most large-scale happenings. But certain happenings, like the burning of a candle, the rusting of iron or the making of a magnet, are concerned with the movements, not of visible pieces of matter, but of very minute particles, such as atoms, electrons or protons.

Scientists would have liked to picture how the atoms moved in a burning candle, or in rusting iron, as clearly as they can picture the

motions of the levers of a typewriter. But we cannot give this sort of clear visual explanation of atoms, still less of electrons, protons or waves. They cannot be pictured, because they are so very unlike anything that we can picture. So there are many cases, particularly among very small-scale events, where we can describe what happens, but not always explain it.

Science tries to put its descriptions in the form of laws. Scientific laws simply state that some event has always been found to be connected in a certain manner with some other event. Thus the law that the *apparent brightness of a point-source of light varies inversely as the square of our distance from it* is not a law in the legal sense, for it does not command lights to behave in this fashion. It is a brief statement of the way the apparent brightness of all lights that have been observed has been found to vary with their distances and, since no exception to the rule has yet been found, we suppose with high probability, but not with certainty, that none will be found in the practical cases to which we wish to apply it (for example, in the calculation of the right distances and brightness of street lamps to illuminate a given stretch of road). Scientific laws are usually very reliable, but they can never be infallible, because one day we may find some case that does not conform to them and thereby exposes their limitation.

Laws of Motion

The fundamentals of science are *length*, *time* and *mass*. We have no difficulty in understanding length (Fig. 2A). We keep a certain standard of length, the metre, marked on a piece of platinum in Paris, and this is the measure of all lines. A surface is measured by an area, which is defined by two lengths multiplied together (see Fig. 2B), while a volume (or bulk) is defined by three lengths multiplied together (see Fig. 2C).

Time is not so simple. We cannot easily define it, but we measure it by motions which we suppose to be steady. We believe that the Earth rotates smoothly and uniformly. The time of one rotation we call a day, and $\frac{1}{86400}$ part of it is our scientific standard of time, the second.

Mass is a little less familiar. We might say it is the quantity of matter in a body. But what is matter? Well, it is very commonly said to be that which has mass, and like time and space, it is not very easily defined. All the things we can touch and handle and which have weight and require force to move them are matter: I and my pen and the paper, this book, the Earth and the Sun, and so forth. A cubic foot of lead is said to contain more matter than a cubic foot of wood, because the Earth attracts the lead about twelve times as much, and also because the cubic foot of lead needs twelve times as hard a push to set it moving at a given speed. But there are difficulties. Are light-waves matter? To this we usually say no. Is an electron matter? We usually say yes. In this region of the very small we find some difficulty in knowing what to call material, but in the domain of the visible and tangible there is no trouble.

Our standards of mass are the pound or kilogram, the mass of certain pieces of metal preserved in London and Paris, and we compare

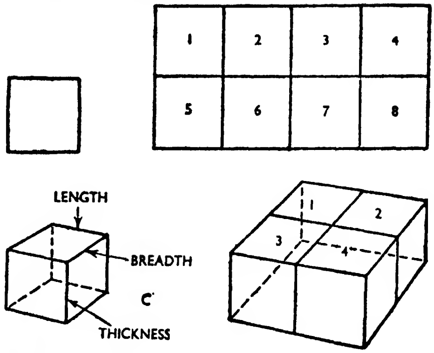


Fig. 2. *Measurements of dimension:* A—*length,* B—*area (length × breadth), and* C—*volume (length × breadth × depth). Standards of length are kept in London and Paris.*

by measuring their weights (the pull of the Earth upon them). A body with a weight equal to a force of 2 lb. weight will have twice the mass of one with 1 lb. weight, and so forth. The weight of a body varies from place to place, but its mass does not. Thus a body that weighs 10,000 lb. at the Equator will weigh 10,005 lb. at the North Pole and only 1,650 lb. on the Moon, but its mass is always the same, and, wherever it is, it will always weigh 10,000 times as much as the standard pound weighs in that place.

Mass, length and time can be combined to give a number of other quantities, such as velocity.

Everything is either at rest or moving with regard to a given observer. We can describe that movement by its direction and velocity. The velocity of a body at any moment is the distance it would travel in a unit of time if its speed remained steady. So we can speak of a velocity of 60 miles per hour or 7 centimetres per second, even though the velocity changes before the hour or second is up.

These velocities are always relative to some other object. Thus a snail may be moving half an inch per second with reference to the leaf it crawls on, but at 200 miles per second with reference to some distant star. Velocities may be speeding up (accelerating) like that of a falling stone, or uniform, or slowing down.

It used to be thought that a moving body needed some force to keep it in uniform motion, but we now reverse this and say that once a body is in motion it continues to move at the same speed and in the same direction, and that if it stops or turns the change is due to a force. But in practice, upon Earth, no body is ever uninfluenced by forces; thus we suppose a meteorite might continue to speed through empty space for eternity, but on Earth all moving bodies slow down because they rub against the air or any other bodies and set their atoms into the confused motion that we call heat. So all earthly motion is being slowed down and turned into heat—usually imperceptible but sometimes noticeable enough, as when one feels the brake-blocks of a bicycle after using the brake on a long hill.

Forces and Acceleration

When the speed of a body is increased or decreased we say then that a force is acting on it. When the bicycle speeded up as it passed over the brow of the hill, the force

of gravity caused it to do so; and when it was slowed down by the brake, it was the force of friction that slowed it down.

There are apparently a great number of forces in the world: gravitation, friction, the pull of a rope, the tension or pressure of a spring, the pressure of water in the pipe; but science reduces them to three: gravitational, electrical and magnetic forces. Thus friction is really the electrical forces between the atoms of the wheel and the brake-blocks. It is meaningless to ask what a force is; science cannot explain *how* the Earth speeds up the bicycle or the magnet draws the iron, but science tries to show that all forces are gravitation, electricity or magnetism in operation. Nothing, even when at rest, is ever without the action of forces. My inkpot is at rest on the table because gravitational force between it and the Earth is pulling it down, and the electrical repulsion between its atoms and those of the table is, to some extent, pushing it up.

Measurement of Forces

We measure forces by comparing them with weights. By a force of 5 lb. weight we mean a force which will just raise 5 lb. from the ground, that is to say, a force five times as great as that with which the Earth attracts the lump of metal which we call the standard pound. The most familiar force is gravitation, for we are never without it. From the earliest times men realized that heavy bodies "tended" towards the Earth, but it was Sir Isaac Newton who put forward the theory that every piece of matter attracted every other piece of matter, and so explained both the falling of bodies to Earth and the motions of the solar system. One cannot easily show that two ordinary-sized bodies, say a couple of jam pots, attract each other, since the force of gravitation is so minute that the attraction of even a pair of heavy objects is very small; thus the attraction between two large locomotives on adjacent lines is less than the weight of a halfpenny. But the mass of the Earth is so gigantic that it attracts everything on its surface with a very considerable force, as we are disagreeably reminded when we come near to the edge of a precipice.

If we let go of a body it attracts the Earth and is attracted by it and moves towards the Earth, that is to say, it falls. But all the time it is falling it is still being attracted and so it moves faster and faster, that is, with an accelerated motion. In the first second it moves sixteen feet, in the second forty-eight, in the third eighty, and so forth. All falling bodies have the same acceleration. Thus a 1 lb. weight and a 100 lb. weight dropped from a window reach the ground at almost the same time. The Earth attracts the heavy weight a hundred times more than it attracts the lighter, but it needs just a hundred times the force to set it moving, and the final result is the same. If no air is present, the weight of a body makes no difference to its speed of fall. A feather and a penny fall at the same speed in a vacuum. A falling body has an acceleration of 32 ft. per second, that is to say, at the end of each second it is travelling 32 ft. per second faster than at the end of the previous second. So after a stone has been falling for 4 seconds, its speed will be $4 \times 32 = 128$ ft. per second (nearly 90 miles per hour).

The distance in feet through

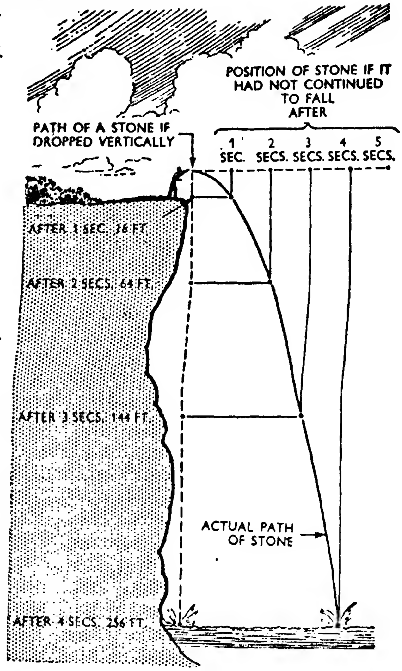


Fig. 3. *Diagram illustrating how the uniform horizontal motion and accelerated vertical motion of a projectile make it move in a path called a parabola.*

which it falls is found by multiplying the time of fall by itself and by 16. Thus if a stone takes 3 seconds to fall to the bottom of a well this must be $3 \times 3 \times 16 =$ 144 ft. deep.

In these calculations no allowance is made for the resistance of the air which makes the motion of all falling bodies slower, but especially affects those whose surfaces are large in proportion to their weights. A slowly moving body feels hardly any resistance from the air unless it is very large and light, such as a newspaper or a cushion. Thus, as we walk, we are not conscious of this resistance, but as speed increases it becomes very noticeable. Streamlining, which is the form which enables a body to pass through air with the least resistance, is useless to a taxi, valuable to an express train, necessary to a racing car and absolutely vital to a high-speed plane, a rocket or shell. As a stone falls and its speed increases, air resistance mounts up and the slowing of the stone by it finally balances the acceleration of its fall, so that a body falling through gas or liquid accelerates less and less until it reaches a steady uniform speed: the terminal velocity.

Measuring Acceleration

Everyone knows that objects accelerate when rolling or sliding down a smooth slope. If we divide the acceleration of a freely falling body (32 ft. per second, every second) by the number of feet, we have to move along the slope in order to rise or fall one ft. vertically, we get the acceleration of a body rolling down that slope. So if a bicycle is running down a slope of 1 in 6 (measured along the road-surface), then it should accelerate at the rate of $\frac{32}{6}$, i.e. $5\frac{1}{3}$ ft. per second (about $3\frac{1}{2}$ miles per hour) every second; so, after 5 seconds it should be doing $17\frac{1}{2}$ miles per hour. The friction of the tyres and bearings and of the air makes the acceleration somewhat less than this.

Suppose a body, instead of being

dropped, is thrown horizontally as in Fig. 3. Its forward motion continues, but it also falls with the same acceleration as it would have had if it had been dropped vertically. Consequently, a stone thrown horizontally and a stone dropped vertically reach the ground together. The forward and downward motions of the stone combine and the stone travels in a curve called a parabola. The curve of a cricket ball or the jet of a fire-hose is nearly a parabola, but is made somewhat steeper at the latter end by the effect of resistance. Fig. 4 shows both the parabola that a shell would describe if there were no air and its actual path of travel.

Work and Energy

A force does not do any work unless it moves. If a grandfather clock is wound up but is not started, the weight exerts a *force*, a pull on the string it hangs by, but while it hangs it does no *work*. Once the clock is set going, the weight descends and turns the machinery, so doing work in overcoming the friction of the moving parts. As I sit on my chair it presses on my body; it is exerting force but doing no work. But if I sit in a lift which moves me from the first to the second floor, that force is moved and work is done by the lift. Anyone who has lifted weights knows that the heavier they are and the farther they have to be lifted, the more the work he has to do. Work then is defined as *force* × *distance*. Thus if a force of a pound-weight moves through a foot, a foot-pound-weight of work is done. The quicker the work is done the greater the power of the doer, so power is work divided by time, and the usual unit of it is a horse-power—33,000 foot-pounds-weight per minute.

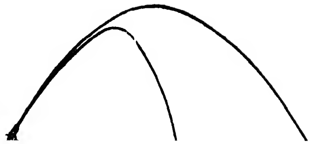


Fig. 4. *Path of a projectile fired from a gun in a vacuum (upper curve) compared with its path when fired in air (lower curve).*

Anything that has the ability to do work is valuable to Man, and so the ability-to-do-work has received the special name of energy.

It is obvious that there are a great many things with the ability to do work, that is to move bodies against forces. Any moving body, such as a runaway train or a rapidly running river, will do work by setting something else in motion: it is said to have Kinetic Energy. But bodies that are not moving, but would move if released, are capable of doing work: for example, a wound-up clock-weight, or the water in a lake a thousand feet above sea-level. These have Potential Energy. Compressed air or steam will move a piston against the resistance of the machinery it drives, so they have potential energy; so has a coiled spring. This is easy enough to see, but some forms of energy are not so obvious.

A charged electric battery can do work by driving a motor, and so has more energy than a discharged battery. A hot body, such as a fire, has energy, for it can be made to drive an engine. Petrol has energy; so has dynamite; so has a loaf of bread, for it can be used to work the motor of Man's body. These last three have chemical energy in some form, energy which is given out when the

substance is changed into something else. Light has energy (radiant energy)—for if you concentrate it by a burning glass it will give heat, which we have seen to be energy.

Everything in the World, indeed, has some energy, for everything is warm. Some things do not feel warm, but everything could be colder than it is and so could theoretically give up its heat to an engine colder than itself and do work. This, however, is not useful energy. The quantity of heat in the sea, for instance, is stupendous, but we cannot use it, first because heat will flow only to something colder and we have nothing colder; and secondly, because, even if we had, our engines are not capable of making use of small temperature differences. But the heat energy of matter is practically negligible compared with its internal energy. We all know today, that every bit of matter contains unthinkably gigantic stores of energy locked within its atoms; if we could use and control this, there would be no limit to the material progress of Man. But we can only release some of the energy from one or two rather rare kinds of atom and we cannot yet forecast how much energy they will be able to give us, or how long the supplies of them will last.

So, for our purposes, energy means useful energy—and that is Man's chief material need. When he buys coal, wood, electricity, gas, oil, petrol, he is buying energy—and the same is true when he buys bread and butter and beef. For all of these he buys in order to turn them into heat or work or both.

Now all these different forms of energy can be changed into one another, according to an exact tariff: so much heat will give so much work; so much work will give so much electricity; so much electricity so much light; and there are no losses on the balance sheet.

Useful Energy

We often cannot completely transform the energy we buy to the kind we want, but none is ever lost, for it reappears in some different form. Thus we buy electricity to put through a lamp to give us light; unfortunately, only 3 per cent of its energy appears as light, but the remaining 97 per cent appears as heat. Twenty per cent of the energy of petrol is turned into the power that drives the car. The other 80 per cent appears as the heat of the engine, the exhaust, the bearings, etc. The tragedy of Man's use of energy is the way in which all of it becomes dissipated into low-grade heat energy, which is of no further use.

Consider the way in which the energy of the light from the electric lamp by which you may be reading came into being. Three hundred million years ago the Sun, as now, was continually turning its heat energy into radiant energy (light) which travelled to the Earth. The green plants in ancient forests turned this into chemical energy, by the aid of which they turned air and moisture into their stems and leaves. These plants became fossilized and formed coal. The coal was dug up and burned in the furnace of a steam-engine, and its chemical energy was changed to heat energy. The steam-engine turned this into the kinetic energy of the rotating shaft which drove a dynamo. This turned the kinetic energy into electrical energy, which in the

filament lamp became heat energy and light energy.

In every one of those six transformations from the Sun's light to the lamp's light a proportion of energy was wasted in heating the air or surrounding bodies, and last of all the light itself fell on the walls of the room, the book you are reading and so forth, and it warmed them, too. Thus it has all changed into low-grade useless heat.

The Sun's Energy

All our civilization and indeed our very life depends upon energy, and all energy has come and still comes from the Sun. The Sun's energy comes from the building up of hydrogen atoms into heavier atoms in its incredibly hot interior. But the Sun's energy is travelling, age after age, into space at the rate of 1,700 horse-power per square foot of its surface, and whatever may be the source of that energy, it cannot be inexhaustible, because energy cannot be made out of nothing. The Sun and every star must some day cease to radiate, and the Universe settle down to a "heat-death" in which there is no other energy than the uniform faint heat of the nearly cold suns and worlds. Or so, at least, it seems to us, when we presume from three centuries of science to predict what may happen millions of millions of years from now.

We have seen that, as far as we can tell, matter can be changed into energy in the incredibly hot furnace of the Sun's interior, and this transformation has been established by electrical experiments in the laboratory. But we may say that the sum total of matter and energy taken together, is never altered, and that as far as we can see, the grand principle of the Universe is conservation. Nothing comes from nothing; all things change, but neither matter nor energy is destroyed. The scientist has found this to be so universal a rule, that he never interests himself in perpetual-motion machines. Anything that professes to produce a perpetual stream of energy without transforming something into it is so entirely contrary to the whole of science that he will not bother to investigate it. Furthermore, matter is not changed into energy nor energy into matter in any of the ordinary operations of nature. Thus, for all practical purposes we may consider that the sum-total of matter and the sum-total of energy remain almost unchanged under the conditions that, at present, obtain upon this Earth.

What is Matter?

So the scientist's world consists of matter, which has mass (or weight) acted upon by energy (that which can set matter in motion). So it behoves us now to look a little more closely at what matter and energy are thought to be.

Matter, in all its various forms—air, water, iron, cheese, pickles, gold and cow-dung—what can we say that is true of all of these? We have already said two things: that they take up space (so that where one piece of matter is, another cannot be at the same time) and that energy is needed to set them moving. But that is to say no more than the savage knows—though he may not be able to express it. The scientist can say more than this, for he can say that all these are made up of an enormous number of very small separate particles, which exert upon one

another forces of attraction and repulsion.

First, however, let us consider a few reasons for thinking that matter is made up of separate little bits, and is not continuous as it seems to be. There are some very convincing demonstrations that show us the effects of these separate bits, but for the moment we will think of reasons that can be understood by those who know little or no science—many of which reasons were considered two thousand years ago by the Greeks, who seem to have been the original inventors of the idea of atoms.

Everyone knows that matter can be mixed—that sugar and water make a liquid in which both sugar and water exist as such and can be recovered, and in which they are so intimately mixed that even the tiniest portion of the liquid contains both sugar and water. So with solids—every tiniest fragment of a penny contains both copper and tin; so with gases—every portion of the air, however small, contains both oxygen and nitrogen.

Particles of Matter

Now, if water is a continuous substance with no spaces or interstices, how could sugar penetrate into it? But if sugar and water are made up of separate particles they can obviously be mixed, just as wheat can be mixed with maize, or soot with flour. Again, all matter can to some extent be compressed into a smaller space or expanded into a greater, gases very greatly, solids and liquids very little, but all to some extent. It is hard to picture a continuous substance as being expanded or compressed, but if matter is made up of particles, the spaces between them afford a ready explanation of this contraction or expansion.

But there must clearly be something about matter besides particles and empty space, because when we try to compress water, although it yields, it does so only when very great pressure is applied, so much so that the greatest pressures that engineering can produce are not sufficient to squeeze a quart of water into a pint pot. So evidently something resists an attempt to bring atoms together, and we suppose that when they are brought near they repel each other with great force. On the other hand, when you fill a tumbler with water it does not instantly disperse itself in every direction, so clearly the particles must not only repel each other when they are forced together, but also attract each other.

Do Particles Move?

Matter in general, then, is thought of as made of particles that attract each other at distances not much greater than their own diameter, but which repel each other when brought very close. Do these particles move? Here again science answers: yes. They are always moving; the motion is what we call heat and would only cease at the complete cold of the absolute zero, which has never yet been attained. How do we know they move? In a room, the air of which is perfectly still, uncork an ammonia bottle. The gas is very soon smelt in every corner, so the ammonia particles must be moving to find their way there. Or, more convincingly, drop a little pool of red ink on the surface of a bit of clear jelly. In a day the red dye from the ink will enter half an inch or so into the jelly. There are no currents in the jelly to carry

the particles, so it is evident that they travel through it by their own motion.

The particles of solids merely vibrate and do not wander about, as we may see from the fact that impressions of fern-leaves in coal have not begun to lose their form in 100 million years. The particles of liquids and gases, on the other hand, continually wander from one part to another, travelling with the speed of bullets and colliding with each other millions of times a second. So the scientist's view of matter is of countless tiny particles which attract each other as a whole but which never can be forced into contact because their outward parts repel each other so strongly. The reason for this appears on page 32. These particles are in motion, and so have energy, and that energy of motion we identify with heat. But there is always another question to ask, and so we find ourselves inquiring what these particles are and what is this energy which they possess.

Molecules and Atoms

Science has shown that there are a large but limited number of pure substances, by which we mean kinds of stuff that have no other kind of stuff mixed with them. Toffee is not a pure substance, for it is a mix-up of any quantities of butter and sugar you may choose, or be able to use; but sugar is a pure substance for it is all made of sugar and nothing else. So again copper is a pure substance, but brass is not, being a mixture of copper and zinc. So when the chemist has sorted out all the mixtures in the world into these pure substances he finds himself with about half a million different kinds of stuff. Sugar, copper sulphate, quartz, salt, gold, aspirin, Epsom salt, naphthalene, alcohol, are pure substances; but strawberry jam, brass, glass, granite, wood, are not.

Now one of the chemist's main jobs is to find out what things are made of. He finds that each of these mixtures is made of several pure substances, and that each of these pure substances is made up of countless millions of minute particles all exactly alike in any one substance, but different from those of any other substance. He calls these particles molecules. He has discovered by ingenious detective work, which has continued for a hundred and fifty years, that the particles of each of these half-million pure substances are made out of combinations of particles of two or more of the ninety substances he calls chemical elements.

Thus the particles of sugar and starch and glucose and aspirin and alcohol and carbolic acid and cellulose and citric acid (and perhaps 100,000 other pure substances), are all made out of different combinations of the particles of the three elements carbon, hydrogen, and oxygen (Fig. 5).

The ninety elements are each made up of one kind of particle, called an atom, and the particles of all other substances are made out of these. It is the chemist's job to find out what atoms form the molecule of a compound, and discover how they are arranged. So after many years of research he can show us the difference between the make-up of aspirin and alcohol and carbolic acid by Fig. 5, which shows how the atoms of the elements carbon, hydrogen and oxygen—here magnified 100 million times—are grouped

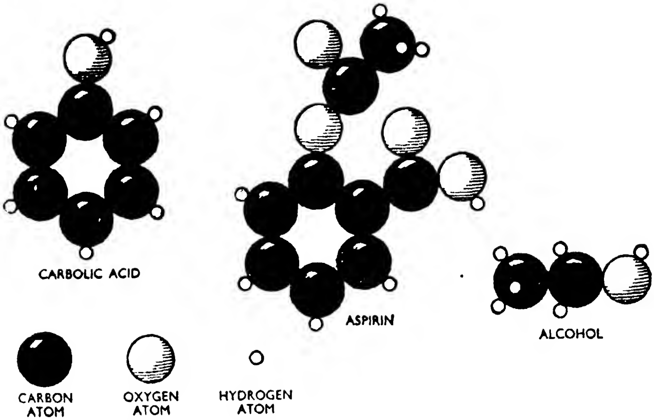


Fig. 5. *Models of carbon, oxygen and hydrogen atoms, about 100 million times larger than their actual size. Above are combinations of these atoms which form molecules of carbolic acid, aspirin and alcohol, respectively.*

into their smallest particles, their molecules, of these substances. Atoms, of course, are not little solid balls, as drawn here, but each atom does consist of a spherical territory into which no other atom can enter. So although atoms are very complicated mechanisms, with no definite shape or surface, we do not commit any error in representing the manner in which they are grouped by drawings or models composed of little spheres.

The molecules into which these atoms are grouped, are strong little structures which are not easily forced out of shape. They attract each other fairly strongly but can be separated, which of course we do to aspirin when we break up a tablet, or to alcohol when we mix a whisky and soda. But it is by no means so easy to separate the parts of the molecules themselves. Heat will often do it: if you put a bit of sugar on a hot stove so that it turns black and steams and smokes and smells, the sugar molecules are broken up into carbon and steam and various highly odorous gases. Sometimes a shock will do it, as with T.N.T. or nitro-glycerine.

Molecules can be fairly easily broken up into smaller molecules or into atoms; but the atoms themselves are totally unaffected. Only two kinds of atom, the 235 "isotope" of uranium and that of the artificially made element of plutonium can at present be broken up by Man on the large scale, and this with the terrible effect seen in the atomic bomb.

We picture matter as made not merely of particles in motion, but particles built up of regular structures of atoms, each a storehouse of energy, locked from Man's grasp.

Energy

So much then for matter. The other form of existence that science recognizes is energy. Energy is possessed by matter in motion,

external motion as of the flying bullet, or internal motion as of the red-hot poker; it is also possessed *by matter which has powers of* attraction not yet satisfied, as of the clock-weight for the Earth or the magnet for iron, and many other examples which are too numerous to mention.

But is there anything in the world which science studies that cannot be considered as matter, either in motion or exerting attraction? Obviously, for there is light, and all those phenomena that we group together and know as radiation.

How Energy Travels

There are a number of instances in which energy, the power of doing work, travels unaccompanied by what we normally call matter. Light can do work; concentrate it with a burning glass and let it fall on a black substance and it will produce heat—and heat is capable of doing work. So light must be energy. We shall have more to say of it, but for the present we may note that X-rays, ultra-violet rays, light, infra-red rays and radio waves, all that we call radiation, are all forms of energy. They all behave as waves; thus two rays of light can give darkness—no light—as two sets of waves can cancel each other if the peaks of one fall into the troughs of the other. They cannot be matter in the ordinary sense, because two bits of matter cannot cancel out; furthermore, all kinds of known matter have mass and therefore weight, and we cannot discover any increase of weight when light is absorbed; thus when sunlight falls on a blackened sheet of metal it does not make it heavier.

So radiation consists of waves; but what is it, you may ask, that is waving? We can understand waves in water or air, but light can travel through the most perfect *vacuum we know of,* the spaces between the stars. Here is an unsolved problem. At one time physicists thought that all the spaces between matter were filled with a jelly-like ether, and light was the wobble of the jelly. But since we have understood light to be an alternation of pulses of magnetism and electricity (page 55), we have had to give up theorizing about the ether, and all we say of light now is that it is a stream of waves, and that we find no need to ask what they are waves in.

Light and all other kinds of radiation, like matter, seem to be divided into particles. As you cannot have less iron than one atom, you cannot get less light than one quantum, a very small amount. The shorter the wavelength the bigger the quantum. If the wavelength could be short enough, one single quantum could have all the energy of the Universe: so, some have thought, the Universe began.

So, finally, the scientist's world consists of molecules and atoms and quanta of radiation—bits of matter and bits of energy—in a mysterious space which is not filled with any *thing* in the usual sense, but which is capable of transmitting forces.

Space and Force

All this is very odd. This space seems to be nothing, but it can be a medium of force. A magnet attracts iron, and the Earth attracts the Moon, through empty space; light is some affection of this space; the particles of which the atoms are made (electrons and protons), seem to be no more than space in a state of strain. We do not understand

this. Einstein describes forces in terms of curvature of space-time, and the whole World, matter, force, radiation, can be thought of as a tortuously curved space-time. Yet this tells us no more about what things are. It seems that, fundamentally, all things are one thing: but we cannot describe that one, because naturally we can have no terms in which to describe it. So, finally then, we need not think of the Universe as particles of matter interspersed through empty spaces, but as a vast extent of space-time curiously curved and contorted so as to bring about the appearance of matter and radiation as we know it.

Leaving aside space-time, the one and universal thing, we find our complicated world is made up of a very great number of very simple things. Coming from the complex to the simple we reduced all radiation to separate quanta and all matter to atoms, but we can reduce these atoms further still. Science has managed to deduce what atoms are made of, and it turns out that all the atoms of all the ninety elements—all the known kinds of atoms in the Universe—are made up of only three kinds of particles: protons, neutrons and electrons.

Ultimate Particles

There are actually six kinds of ultimate particles, but only these three exist permanently in matter. The electron is light in mass and has a strong negative charge; the proton is heavy and has a strong positive charge; the neutron has no charge and has the same mass as the proton. These are the stuff of which all matter is made. The simplest atom, that of hydrogen, is made of one proton and one electron. The most complicated of the natural atoms, that of uranium, has 92 protons, 146 neutrons and 92 electrons. Plutonium, artificially made for the atomic bomb, has 94 electrons and 94 protons in its atom. Protons and neutrons are about 1,800 times as heavy as electrons, and these protons and neutrons are all contained in a minute but heavy nucleus, which remains at its centre, while the light electrons form a bulky cloud around it. Thus the typical atom may be shown as in Fig. 6.

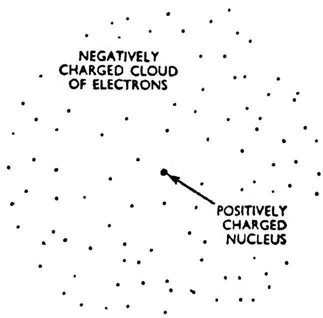


Fig. 6. *Nucleus surrounded by a cloud of electrons in a typical atom.*

The electron cloud is negatively charged, and since negative electricity repels negative electricity, the outsides of atoms being all negative, repel each other. At the centre is the nucleus, minute compared with the atom (so small in fact, that if the atom of Fig. 6 were drawn to scale, we could hardly see it), yet this minute nucleus, in a space believed to be no bigger than one electron, contains the whole mass and positive charge of some dozens of protons.

We can scarcely form any notion of what this minute interior of the nucleus is like: when nuclei

start exploding, cities are blasted out of existence.

Roughly speaking, we may say that it is the outer cloud of electrons and its arrangement that gives the ordinary kinds of matter their properties. Thus copper is red-brown, and is corroded by nitric acid and forms a blue sulphate and conducts electricity, all because the electrons in its outer cloud have a certain pattern; this cloud is the only part of the atom that comes in contact with the outer world, so it is the means by which we know copper. The nucleus of the copper atom, on the other hand, gives the copper its weight, and binds the electrons into the outer cloud, and so makes them distribute themselves into the pattern that makes copper what it is.

The Size of the Atom

We have already given the idea that molecules and atoms and the ultimate particles are very small; but it is not easy for us to picture just how small they are. Let us start with atoms. The different atoms do not vary very much in size, and we may take the oxygen atom as a fair sample. Its diameter is rather less than a hundred-millionth of an inch. If all the people in the World could somehow count the atoms in the tiniest speck of matter you can see, for eight hours a day at the rate of four atoms a second, they would get through their task in nine months. It is not really possible to picture anything so small, but the best idea can perhaps be gained by saying that if a postage stamp were magnified to the size of the United States, the atoms of which it is composed would look about as big as golf-balls.

Molecules are made up of many atoms, and some contain three or four thousand of them. Thus, the molecules of a simple substance such as water, are scarcely bigger than the atoms we have mentioned, while the molecules of some complicated compounds found in animal tissues are not very far off the range of visibility of the most powerful microscopes.

Electrons and protons are far smaller than atoms, and nobody knows quite how small they are. But even if our model of a postage stamp with the atoms and electrons and protons in it could be made so large that it would cover the whole world, the electrons and protons in the atom would still be far too small to be visible, except perhaps as specks like motes in a sunbeam. That men have learnt so much about these utterly minute particles is a vivid commentary upon the power of modern science. We can, in fact, make a precise map of a molecule ten thousand times smaller than the smallest thing the microscope can show us. The layman may be tempted to wonder if scientists really do know all these things about atoms they can never hope to see. The answer is Hiroshima.

The study of molecules, atoms, protons and electrons, is generally considered to be a part of physics, but the study of the different kinds of matter that are made up of these atoms and molecules is considered as being the task of the chemist.

The Chemical Elements

Molecules, atoms, electrons, protons and neutrons are intensely interesting, because they are the simplest constituents of the Universe and because it is possible to explain such a great number of different

phenomena in terms of them. They are, indeed, the foundation and the deepest cause that science has yet discovered of all the happenings of the visible world.

The actual practical observation and experiment, and still more the industrial application of science, does not concern itself directly with single molecules or atoms but with ordinary matter in visible and weighable quantities; that is to say, not with single atoms but with quadrillions of atoms at once.

The outward expression then of the fact that there are atoms of ninety-two different patterns with one, two, three, four, and up to ninety-four electrons in the outer cloud, is that there are ninety-two different kinds of matter. There are ninety-two different kinds of matter which contain no other kind of matter, but out of which all the others can be made, and these are called chemical elements. Some of them are very familiar, such as the oxygen and nitrogen of the air we breathe, the carbon that makes up charcoal and coke, and the various common metals: gold and silver, iron, copper, lead and so forth. Other elements, though very common, are only met with in their compounds. There are countless millions of tons of sodium and chlorine in the salt of the sea, but most of us have not seen either of them (except perhaps, in a school laboratory), because they cannot exist unchanged in presence of air or water, but combine with them and make various compounds.

Periodic Table

The Table on this page lists the chemical elements arranged according to what is called the Periodic Table. The elements are arranged according to the weights of their atoms (or better, according to the number of electrons in their atoms), and the result is that they fall into vertical groups, the members of which have the same pattern of atom and so are similar in their chemical behaviour.

There are two great classes of elements—metals and non-metals. We all of us have some idea of what is meant by a metal. All the metals have that particular shine which we know on silver or steel or brass, and which is quite different from the shine on glass or crystal or polished stone. They all conduct electricity well, most of them are rather dense and require a high temperature to melt them. But we value metals chiefly because they are hard, strong and tough. Being hard they will stand a good deal of

PERIODIC TABLE OF ELEMENTS WITH

Group 0	IA	IB	IIA	IIB	IIIA	IIIB
	Hydrogen (1)					
Helium (2)	Lithium (3)		Beryllium (4)			Boron (5)
Neon (10)	Sodium (11)		Magnesium (12)			Aluminium (13)
Argon (18)	Potassium (19)		Calcium (20)		Scandium (21)	
		Copper (29)		Zinc (30)		Gallium (31)
Krypton (36)	Rubidium (37)		Strontium (38)		Yttrium (39)	
		Silver (47)		Cadmium (48)		Indium (49)
Xenon (54)	Caesium (55)		Barium (56)		Lanthanum and fourteen rare Earths (57-71)	
		Gold (79)		Mercury (80)		Thallium (81)
Radon (86)	Caesium (87)		Radium (88)		Actinium (89)	

rough usage without losing their shape, being strong they will support heavy weights, and being tough they will bend or dent without breaking. These qualities make them supreme for engineering work. Steel is the hardest of the common metals and the strongest; copper is the toughest.

Not all metals have these qualities. Lead can be cut with a knife; a stick of sodium as thick as a candle requires no very strong arm to pull it asunder; antimony can be splintered by a fall on a stone floor.

Only a few of the seventy-two metals are used to any extent in industry: most of them have some good quality that others have not, but in many cases this is neutralized by the rarity of their ores, or the difficulty of smelting them, or the fact that they are easily corroded by air and moisture. Thus, of the fifteen metals of Groups I, II and III (below) only three—beryllium and magnesium and aluminium—are of much use: their merits are strength and lightness, and they are used alone or as alloys for aircraft parts, etc. In Group IV tin and lead are both useful, because they melt very easily and resist the action of water and weak acids. Tin is non-poisonous and so can be used to coat steel plates to make what we call "tins"; lead is very poisonous and so must not come into contact with foodstuffs, but its flexibility makes it invaluable for pipes and roofing. Antimony is useful for making castings (as in type metal), because it expands as it solidifies from the molten state and so fills the mould excellently.

In Groups IIIA, IVA and VA are twenty-six metals mostly rare or difficult to make, none of which has found much use, but chromium, molybdenum and tungsten and manganese in the next groups, when mixed with steel make it very strong and tough. Uranium, the last of Group VIA, is one of the known sources of atomic energy, and has, in fact, been used for that purpose.

In Group VIII is iron, the metal of supreme importance. The industrial achievement of Man hangs upon the use of iron and steel; and it likewise seems to be one of the chief materials of the Universe. When meteorites from outer space arrive on this Earth, they are usually found to be mainly composed of iron. Moreover, the whole Earth itself is five and a half times as heavy as an equal globe of water, whereas its crust is only about two and a half times as heavy: so it is concluded that the deep interior of the Earth is mostly made of iron, which is seven

ATOMIC NUMBERS IN PARENTHESES

IVA	IVB	VA	VB	VIA	VIB	VIIA	VIIB	VIII
	Carbon (6)		Nitrogen (7)		Oxygen (8)		Fluorine (9)	Iron (26)
	Silicon (14)		Phosphorus (15)		Sulphur (16)		Chlorine (17)	Cobalt (27)
Titanium (22)		Vanadium (23)		Chromium (24)		Manganese (25)		Nickel (28)
	Germanium (32)		Arsenic (33)		Selenium (34)		Bromine (35)	Ruthenium (44)
Zirconium (40)		Niobium (41)		Molybdenum (42)		Masurium (43)		Rhodium (45)
	Tin (50)		Antimony (51)		Tellurium (52)		Iodine (53)	Palladium (46)
Hafnium (72)		Tantalum (73)		Tungsten (74)		Rhenium (75)		Osmium (76)
								Iridium (77)
	Lead (82)		Bismuth (83)		Polonium (84)	—(85)		Platinum (78)
Thorium (90)		Protoactinium (91)		Uranium (92)		Neptunium(93)		Plutonium (94)

and a half times as heavy as water. Some of the other metals of this group, such as cobalt and nickel, are used to improve steel. Platinum in this group and gold in Group Ib are remarkable as being the metals unaffected by air, water and acids; this makes them valuable for jewellery, for dentures and for all manner of scientific instruments that must not corrode. They are rare, but since no other metal shares their qualities, they are won from the earth in considerable quantities. Copper is very useful; it is extremely tough, and a very good conductor of electricity. Alloyed with tin, it gives bronze, nearly as strong as steel and far tougher, and with zinc gives brass, which has a beautiful colour and can be worked perfectly on the lathe.

Finally, there is mercury, that strange liquid metal which finds many uses in scientific laboratories and instruments, especially in barometers and thermometers, but which has very limited uses elsewhere.

The non-metallic elements are not on the whole so familiar, because very few of them are consciously used in daily life. They are not bright, lustrous materials like the metals. Many are gases, and the others are somewhat undistinguished-looking earthy substances.

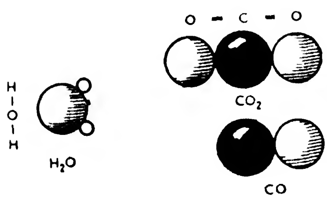


Fig. 7. *Models of the molecules of water (H_2O), carbon dioxide (CO_2) and carbon monoxide (CO).*

Among the gases is hydrogen, which we meet with in balloons. about half of coal gas is hydrogen. Oxygen, which forms one-fifth of the air, is the source of animal life and the supporter of combustion without which no fire could burn. The pure gas is used by acetylene welders and by the givers of anaesthetics. Four-fifths of the air is nitrogen, which chemical works now make into fertilizers. Sulphur has manifold uses—in fungicides, fireworks and the chemical trades; phosphorus in matches and the incendiary bomb. Chlorine, formerly used as a poison gas, is today a bleaching agent and a useful disinfectant, and is important in the chemical trades. Iodine has familiar medical uses. Carbon is the most familiar of the non-metals. It exists in the air as carbon dioxide (see Fig. 7): plants decompose this and use the carbon in their tissues. Plants fossilized give coal, which we make into coke: charred they give charcoal—and so all the carbon we have (except that pure and beautiful crystal, the diamond) has been won from the air by plants.

Chemical Combination

Such are the chemical elements: important enough but very few and simple compared with the hundreds of thousands of pure substances known to Man. All that vast number are built up of molecules put together from atoms of a few (rarely more than five or six) of the ninety-three possible kinds.

Elements usually consist not of single atoms but of atoms of the elements linked together in pairs (or even fours or eights). So we may depict the gases, oxygen and hydrogen, as in Fig. 8.

Now if oxygen and hydrogen gas

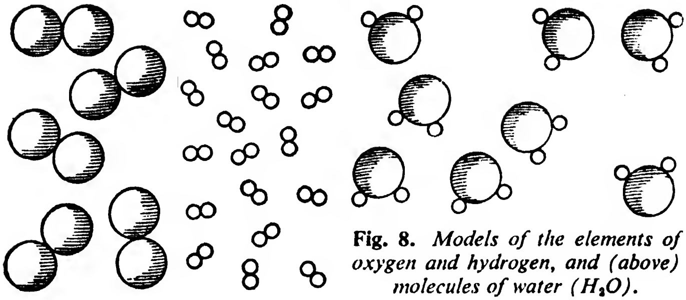


Fig. 8. *Models of the elements of oxygen and hydrogen, and (above) molecules of water (H_2O).*

are mixed and then set alight, there is a violent explosion, and if the vessel is not shattered, there remains in it steam (see Fig. 8) which condenses to water-drops. The atoms have rearranged themselves, so that two hydrogen atoms are attached to each oxygen atom: in fact, they have formed molecules of water (see Fig. 9). This is a typical chemical combination, and we note that:—

(1) A new pure substance has been formed which was not there before, and

(2) There is an energy-change—in this case the production of a great deal of heat.

This is true of all chemical changes. Thus when iron rusts, when a candle burns, when milk goes sour, when a man digests his food—in every case some substance or substances are changed into other and quite different substance or substances, and energy is given out or absorbed—the substances becoming hotter (or sometimes cooler).

Sometimes two or more substances combine to form one, as when hydrogen and oxygen form water; sometimes one decomposes into several, as when trinitrotoluene (T.N.T.) breaks up into carbon dioxide, carbon monoxide, oxides of nitrogen, etc., but these are just varieties of chemical change.

Now this *change of material* is particularly noticeable in living things. In a dead world like the Moon there is probably no chemical change. Everything that will combine or decompose has already combined or decomposed, and the blazing sunlight beats endlessly on bare rock. But on Earth we find chemical changes ceaselessly going on in living things, whose special feature is that they use energy to make complex chemical compounds. The plant starts the ball rolling. The green parts of the plant capture the light-energy from the Sun and—no one knows how—use it to turn carbon dioxide from the air and water, and nitrates from the soil, into the starch and sugar and cellulose and proteins that make up its tissues. These plant tissues are then a store of chemical

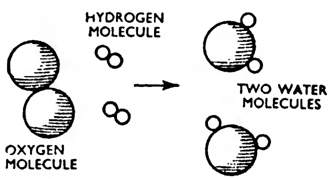


Fig. 9. *How one oxygen molecule and one hydrogen molecule combine and form two molecules of water.*

energy for all other forms of life. Animals eat them and burn the products in their tissues to keep themselves warm; they use them as fuel to provide their energy of movement, and as raw material to make the complex chemicals in their tissues.

Looking at the living world from the point of view of energy, the plant is the transformer of radiant energy from the Sun into the chemical energy of organic compounds; while animals are the transformers of the chemical energy of plants into their energy of motion and heat.

All the energy of combustion that is used in furnaces and power stations ultimately comes from green plants. The Sun's energy formed plant tissues. Plants formed coal; they fed the sea creatures which are thought to be the origin of oil. Our industrial civilization is largely the product of the former activity of dead plants. Nearly all the chemicals we make are made by the use of this energy, though some are made through electrical energy, generated by the power of water, raised to the hilltops by the Sun. Every scrap of energy, and every particle of matter has come from the Sun, and plants are the chief trap for its energy.

Chemical Energy

Now chemical energy, which appears as heat in a chemical change, is Man's source of power and chief instrument. The ancient plants used sun-energy to take carbon from the carbon dioxide in the air, and so made coal. Coal can be turned back to carbon dioxide and so release this energy to drive trains, heat gas-stoves, generate electricity, make chemicals and so forth. Where does the energy of the exploding bomb come from? From the chemical energy of the coal, and that of the electricity (generated from coal) that was used to make it. The explosion is in fact, concentrated sunlight. And the atomic bomb? Just the same. It was in the interior of the Sun, perhaps three thousand million years ago, that the intense concentration of radiant energy—perhaps at a temperature of 40,000,000 deg. C.—locked up the energy in the nucleus of the uranium atom. We do no more than unlock it.

So all the varied changes of the stuffs that make up the living world of the Earth's surface are done by the Sun's energy, degrading itself into low-grade heat. The ray is trapped by the plant: some part of it is turned into chemical energy, some part merely warms the plant. The animal eats the plant. Some of that chemical energy warms the animal, some is turned into motion; the motion overcomes friction and so is transformed also to heat. All the radiation of the Sun ends up as useless low-grade heat, but we borrow it on its way down and by its aid we carry on our lives.

What, exactly, happens in a chemical combination when, let us say, hydrogen and oxygen form water? If the atoms merely stuck together we should hardly expect so much energy to be set free, and actually there is quite a considerable disturbance in the electron-cloud around the atoms. The electrons of the hydrogen atoms enter into the structure of the oxygen atoms, and the oxygen atoms' electrons into the hydrogen atoms' structure, so that the atoms in water are not merely side by side but, so to speak,

grafted one into the other. The whole structure becomes more compact, the electrons come nearer to the nucleus, and so give out some of their energy as heat. If we require to separate these atoms, to turn water back to hydrogen and oxygen, we have to put all that energy back again, so it could never be profitable to turn water into hydrogen and oxygen and burn these for energy.

Chemical Compounds

We have thought of the combination of chemical elements from the point of view of the energy it produces or requires, but we can also look on it from the point of view of the new substances it makes. There are about half a million of these known to science, so it is not very easy to make a brief summary of the different classes of chemical compounds. The usual division is into:—

(1) Inorganic compounds, which are made up of elements other than carbon;

(2) Organic compounds, which are compounds of the element carbon;

and the first class, inorganic compounds, is conveniently divided into (i) compounds of metals, (ii) compounds of non-metals.

Generally speaking metals do not combine very firmly or easily with each other, but non-metals combine with metals and with each other.

Compounds of Metals

Metals fairly easily enter into chemical combination, as may be seen from the fact that no metal, except gold and platinum, remains long without tarnish or rust. All except these combine with the oxygen in the air when they are hot: it is the praise of gold that it withstands the fire, but in truth we should say that it withstands the air. Water and air together corrode most metals to oxides, and carbon dioxide turns many of these into carbonates, while sulphur turns them into sulphides, or, together with oxygen, into sulphates. So whether there are or ever were free metals in the deeper parts of the Earth, they are now transformed into carbonates or sulphides or sulphates and other compounds, and this is how we find them today.

Generally speaking, the crust of the Earth and the minerals found therein are compounds of metals. Salt is a compound of the metal sodium with the non-metal chlorine; limestone is a compound of the metal calcium with the non-metals carbon and oxygen; granite is a mixture of compounds of iron and potassium and magnesium and aluminium with silicon and oxygen.

The most interesting and valuable compounds of metals are the class known as salts, being named after common salt, the best known of them. A salt is derived from an acid (which is a compound of hydrogen with, usually, a non-metal and more or less oxygen) by putting atoms of a metal in place of atoms of hydrogen. Thus, sulphuric acid is a compound of hydrogen, sulphur and oxygen, and its chemical formula is written as H_2SO_4; copper sulphate is a salt of copper and sulphuric acid, made by putting a copper atom in place of the hydrogen atoms: its formula is $CuSO_4$ where Cu stands for a copper atom. It is possible to make a sulphate of this kind from almost any metal, usually (with sodium or potassium this is extremely dangerous) by simply putting the metal in the acid, and, if necessary, heating it.

Sodium sulphate is Glauber's salt, calcium sulphate is plaster of paris, magnesium sulphate is Epsom salt, iron sulphate is "green vitriol" or copperas. These salts have a great number of industrial uses in pharmacy, dyeing, tanning, metallurgy—and indeed, almost every industry uses some of them. They are a very distinctive set of bodies. They usually look very much like common salt, but many of them are coloured. They form good crystals and are generally soluble in water.

From the chemist's point of view their characteristic is that their solutions conduct electricity and are split up or electrolysed by it. Thus, when an electric current passes through a solution of common salt, caustic soda and chlorine appear around the terminals that enter the water, and this is one of the ways in which caustic soda, the foundation of the soap industry, is made. So, also, when a solution of copper sulphate is treated in this way metallic copper deposits on one terminal, the cathode, while sulphuric acid appears at the other, the anode. This behaviour is characteristic of acids, alkalis and salts, and of nothing else (if, for example, an attempt is made to pass an electric current through a solution of sugar, the solution scarcely conducts any electricity and the sugar is quite unaffected). The atoms in these salts are considered to be held together in a very different fashion from that in which the atoms are held together in such compounds as sugar. The atoms in sugar are grafted together by sharing electrons, but those in salts are held together by electrical attraction only.

Thus ordinary salt is sodium chloride. When sodium metal is burned in an atmosphere of chlorine, salt is formed. The sodium atom has one "odd" electron in its outer shell; the chlorine atom lacks one electron to make its outer shell complete. So the electron passes from the sodium atom to a chlorine atom (see Fig. 10). The sodium atom having lost the negative electron becomes positively charged and the chlorine atom by gaining it becomes negatively charged, so the charged atoms or ions stick together by electrical attraction; but they are not made one and can easily be attracted apart. Actually, when dissolved they link up with water molecules and drift apart, and when an electrical current is passed through the solutions the positively charged sodium atoms drift to the negative terminal and the negatively charged chlorine atoms to the positive terminal. Hence the action of the electric current.

It is interesting to note here that

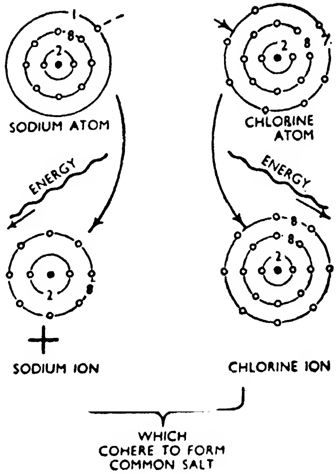


Fig. 10. *How sodium atoms and chlorine atoms make common salt.*

the plan of an atom's electrical structure has provided the key to the relations between the chemical properties of matter.

Compounds of Non-metals

The non-metals—sulphur, phosphorus, nitrogen, carbon—form a variety of compounds, the most conspicuous of which are their oxides (compounds with oxygen) and their acids (compounds with hydrogen and often a third element). Every element except the curious inert gases that are used in electric discharge tubes (helium, neon and the like), form one or more compounds with oxygen, and this is why very few elements are found in nature as such. Nitrogen does not form its oxides at all easily, and that is why oxygen and nitrogen can remain unchanged in the air. Such elements as sulphur and carbon are only found in the depths of the earth, where there is no oxygen to combine with them. The oxides of non-metals are themselves very ready to combine with water, usually to make acids, and these acids combine with the metallic compounds in the Earth's crust to give salts. Thus, nearly all the carbon in the world is in the form of carbonates, such as chalk and limestone; some is in the carbon dioxide present in small quantities in air and natural water, but comparatively little in the free state of hard coal and graphite and diamonds. So with sulphur. It is almost all in the form of sulphates such as gypsum, or of sulphides such as iron pyrites. Nearly all the phosphorus is in the phosphates (see table below).

Some of these salts are important sources of the elements in them to animals and plants. Plant tissues contain carbon and oxygen and hydrogen, which come from air and water, but they also contain nitrogen and sulphur and phosphorus which come from nitrates, sulphates and phosphates in the soil: without these there could be no plants.

Our tissues are built from plant tissues so these salts are an absolute necessity without which we could not hope to live for long.

Organic Compounds

One element, namely carbon, forms compounds which are far more numerous than, and entirely different from, those of any other element. The compounds of carbon with other elements, chiefly hydrogen and oxygen, together with nitrogen and sulphur and occasionally some other elements, are called organic compounds, and the study of them has been elevated into a special department called organic chemistry. Carbon atoms can combine with other carbon atoms and form chains or rings or networks of carbon atoms to which other atoms may be attached. The elements, other than carbon, do not form long chains of this kind, and so the size and complexity of the molecules they form is much inferior. The tissues of plants and

Carbon C	Carbon dioxide CO_2	Carbonic acid H_2CO_3	Carbonates $CaCO_3$ (chalk)
P Phosphorus	P_2O_5 Phosphorus pentoxide	H_3PO_4 Phosphoric acid	$Ca_3(PO_4)_2$ Calcium phosphate

animals are made up of extremely complicated carbon compounds, and it may be said that just as life requires energy to run the living engine, it requires organic compounds to make the living engine. We do not know any other materials susceptible of such variety and continual change, nor do we believe that such exist.

The art of making (synthesizing) carbon compounds instead of merely extracting them from plant and animal tissues is now about a century old, and the vast majority of the carbon compounds we have made have never previously existed in any living creatures. Many of the carbon compounds are essential to industry. All foods are carbon compounds, all dyes, most drugs, all textiles, nearly all explosives, all the plastics, all the oils and fats, all the fuels—so it is no wonder that organic chemistry is continually becoming more important. Not only is it important as furnishing these most important non-living materials, but behind it all lies the secret of life—for the phenomena of life are never observed in any kind of matter except carbon compounds. It is through the medium of a complex delicate network of chains of carbon, hydrogen, oxygen, nitrogen, sulphur, and phosphorus atoms that I, whatever that may be, am enabled to move my pen to express my thoughts, whatever they are.

So the chemist's work is to examine every kind of stuff, discover what elements are in it, and how their atoms are put together to make it. He likewise devises new kinds of matter that never before existed in the World and finds the way to make them. He can set himself a goal, say a transparent plastic or a drug to cure septic wounds, and patiently fashion one material after another until the end of his work is accomplished.

Chemistry and Physics

The chemist studies the different kinds of matter: he wishes to know the qualities that especially distinguish some substance, such as sulphur or sugar or silver, from other kinds of matter, but he is not interested in the properties that are the same for all kinds of matter. Thus, almost any solid melts, when heated, and the chemist records the temperature at which it melts, 114 deg. C. for sulphur or 961 deg. C. for silver, because that melting-point belongs to that particular substance.

The physicist, on the other hand, is interested in the process of melting as such without special regard to what is being melted. But the two aspects cannot be separated because the physicist must necessarily study the melting of particular things, and there is a broad belt of scientific territory common to chemistry and physics; this is called physical chemistry, and is of ever-increasing importance.

Heat

Every kind of matter can be heated. Anything whatever, if exposed to a source of heat, becomes warm. At one time heat was thought to be a kind of stuff, a very subtle and thin fluid which could penetrate into any kind of body. But there was a fatal objection to this idea, namely that you can get unlimited heat out of work. Thus, if a shaft is rotated in an unlubricated bearing, heat is produced where they meet and, as long as the shaft is kept turning, heat will continue to be produced. Nothing

is being put into the system except work—energy—and heat is coming out. Consequently, we believe heat cannot be a kind of matter, for it is here being made from work, which is not matter.

What does work chiefly do? It sets bodies in motion. Now the bearing does not move and the shaft moves the slower for the friction that produces heat; so we may reasonably suppose that the shaft is making something move and that heat is a motion of the molecules of a body. And this is proved to the satisfaction of physicists, because for the last hundred years a vast number of calculations concerning heat have been based upon it and have not let them down.

The kinetic theory of heat, as we call it, supposes that the molecules of all substances are in motion. The energy of that motion is heat, but its velocity determines temperature. In ordinary speech we do not always distinguish heat and temperature, though we understand it well enough. It is commonly known that there is more heat in a tank full of boiling water than in a red-hot poker, though the poker is much hotter. We say this because we know the tank of water would keep a room hot for quite a long time, while the poker would scarcely heat it at all. The tank will do more work, and so has more energy. We say that the poker is hotter (has a higher temperature), because if the red-hot poker is put into the tank of boiling water, heat will flow from the poker to the water. So amounts of heat are measured by the work they will do in heating other bodies.

The unit of heat measurement is a calorie, the amount of heat that will warm a gram of water from 0 deg. C. to 1 deg. C. The unit of temperature is a degree. On the centigrade scale a degree is a hundredth of the temperature difference between boiling water and melting ice.

A universal property of heat is that it causes bodies to expand—to become larger every way. Solids and liquids expand but little, but gases expand greatly. Such expansion is often troublesome: thus, unless special expansion joints are used for steam pipes they will bend and buckle when steam is turned on.

Heat expands the pendulums of clocks and makes them run slow. This expansion has its uses, however, for we measure fairly low temperatures by the expansion of liquids in thermometers (see Fig. 11). The liquid chosen must expand evenly—by the same fraction of its bulk for each degree—and water, which expands unevenly, cannot be used. Mercury and alcohol (usually coloured pink to make it visible) are commonly employed. But all liquids boil at high enough

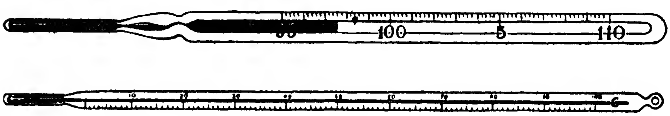


Fig. 11. *(Above) Clinical thermometer and (below) chemical thermometer (not to scale). The thread of the clinical thermometer is really very narrow but the stem is shaped so that it will magnify the mercury.*

temperatures, and glass softens, so thermometers with liquids in them can only be used up to about the melting point of zinc (500 deg. C.). Above this we measure the electrical resistance of a platinum wire, or the electromotive force (e.m.f.) given by two metals in contact; at still higher temperatures we observe the intensity of the light given by the red-hot or white-hot material.

Quantities of heat can be measured by discovering how much they heat a given weight of water. Thus if a flame heated 1,000 grams of water from 10 deg. C. to 60 deg. C. in a minute, it would be giving out $1,000 \times (60 - 10) = 50,000$ calories per minute. The calorie is rather a small unit: in this country the British thermal unit is often employed and is the heat required to raise the temperature of a pound of water by 1 deg. F. The therm by which gas is sold for domestic purposes is 100,000 British thermal units.

How Heat Travels

Heat is the energy of the motion of molecules, and because it is such a motion it travels. If a poker is thrust into the fire, the molecules of the cooler parts are moving more slowly than those of the hotter part. The rapidly moving molecules travel through wider paths and attract and repel the slower moving molecules next to them. These are stirred up and made to move more quickly and are made hotter. So the motion of the molecules is transmitted along the poker and we express this by saying that heat flows from the hotter part to the cooler part. This process is called conduction and is the only way in which heat can pass through solids.

Solids vary much in the speed with which heat passes through them. Metals conduct heat much better than any other kind of matter. Anyone who has used an aluminium cup knows how much hotter it feels than a china cup even though the liquid within is at the same temperature. Heat is conducted so rapidly through the aluminium into the hand that the blood-stream cannot take the heat away fast enough—and so the skin is heated sufficiently to give pain—but the china cup delivers the heat so slowly that the blood-stream can keep the hand that holds it reasonably cool.

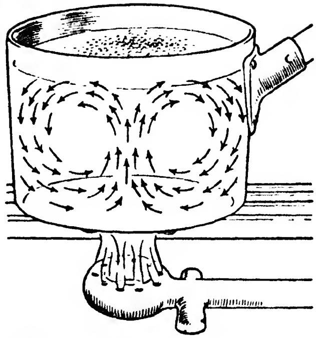


Fig. 12. *Diagram showing the convection currents which are set up as a result of the application of heat to a saucepan of water.*

Liquids and gases are poor conductors of heat, and another process, called convection, comes into play and accelerates the movement of heat in them (see Fig. 12). Anything that is lighter than an equal bulk of a liquid or gas will rise, as a cork in water or a balloon in air rises. A hot-water pipe heats the air immediately touching it by conduction; the air expands and becomes lighter than an equal bulk of cold air around it; it is at once thrust upward by this cold air which takes the place of the hot, and in its

turn is heated and rises. The hot air after rising may cool and sink once more. Thus a circulation is set up, which we speak of as a convection current. Chimneys utilize convection to carry off smoke and bring air to the fires; winds are largely due to the same cause. The domestic hot-water system is operated by convection likewise (the principle of a modern type being shown in Fig. 1, page 18).

Radiation

Heat is transmitted in yet a third way known as radiation. Atoms and molecules are electrical structures and when they move they give out electromagnetic waves (see page 64), longer than light waves but shorter than radio waves. These are called infra-red rays. Every substance is always giving out and receiving those rays, but at room temperature they are given out but slowly. As the temperature rises, so these waves rapidly increase in quantity. So any body hotter than its surroundings will give out more heat waves than it receives and will therefore cool. Hence it is that on clear nights the ground sends out heat waves into space and receives few or none in return. The temperature of the ground therefore falls, and in winter frost, or in summer dew, may form as the result of condensing the water vapour of the air. On a cloudy night these rays are partly reflected back to earth and the cooling is much slower.

Dark-coloured surfaces radiate most easily and bright metallic surfaces least so. Thus stoves should be black, but hot-water cans should be polished.

The vacuum flask (see Fig. 13) is designed to prevent heat from travelling out of its interior. It is a vessel

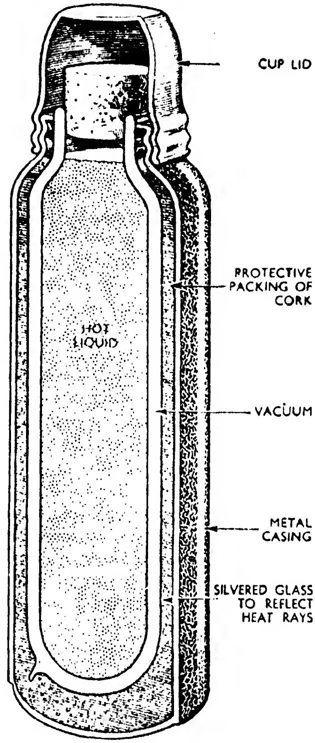


Fig. 13. *Vacuum flask in part section showing how it is constructed in order to prevent rapid loss of heat.*

with double walls from the space between which as much air as possible has been pumped. The inner walls of this space are silvered. Heat can now only be conducted away through the cork and the glass neck—a very slow process—while convection cannot take place because in the vacuous space there is no air to be heated and rise. Radiation cannot be prevented, but the silvered surface is a very poor radiator. It is impossible to make

a wholly heat-proof enclosure, but the vacuum flask is our best approach towards this end.

Solids, Liquids and Gases

One of the most conspicuous effects of heat is the changing of the state of bodies. Ice, a solid, when heated changes to water, a liquid; this when further heated becomes steam, a gas; and similar changes take place in every substance which can be sufficiently heated without breaking up into other substances. We can melt and boil sulphur or naphthalene; we can melt sugar, but if we heat the liquid it blackens and chars before it boils. We cannot melt or boil wood because it breaks up into steam and smoke and charcoal long before it is hot enough even to melt. Melting and boiling are very important operations both in science and industry, and to understand them we must know what is the essential difference between a solid, a liquid and a gas. The obvious external difference is a simple one.

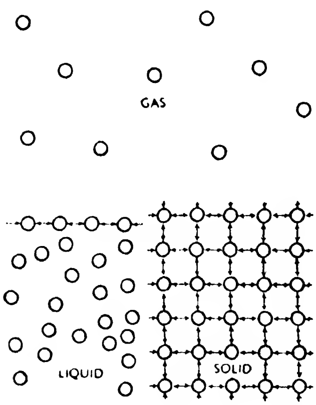


Fig. 14. *Model showing the arrangement of molecules in a solid, a liquid and a gas (all magnified about 30 million times).*

A solid has a fixed volume and shape; thus, a fossil or a crystal of a mineral will keep the same shape and size for 1,000 million years.

A liquid has a fixed volume but no fixed shape; thus a pint of water can be poured into vessels of any and every shape, but it will never be more or less than a pint.

A gas has neither fixed shape nor volume. If a whiff of ammonia gas is released in a room, it will shortly fill the whole of it evenly, as the nose will show: it has taken the shape and size of the room.

Gases

All matter—solid, liquid or gas—is made up of particles called molecules (page 29), all of which are moving: their average speed depends on the temperature. Molecules attract each other, some very feebly, some very strongly. Now if the molecules move fast enough their momentum will be enough to draw them out of range of their neighbours' attraction and they will then move about quite freely. If the attraction between the molecules is slight, then the substance will be a gas at the ordinary temperature, as are hydrogen, oxygen and nitrogen; but if it is strong their speed will have to be increased, that is to say, they will have to be heated before they can get away from each other. Thus, at normal atmospheric pressure, water turns into a gas at 100 deg. C., sulphur at 444 deg. C., iron at 2,450 deg. C., and carbon at 3,600 deg. C. These are the boiling points of these substances.

So we may picture a gas as in Fig. 14, which is enlarged about 30 million times. In every cubic

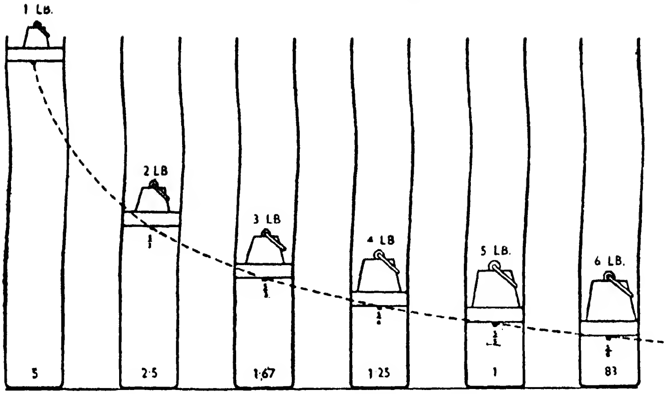


Fig. 15. *Diagram illustrating the principles of Boyle's law. The weights are supported on pistons in cylinders filled with gas at a constant temperature. Thus, the heavier the weight, the more the gas is compressed.*

inch of gas there are about 300,000 billion molecules. The lighter these are, and the hotter they are, the faster they move, but taking oxgen as an example, its molecules at room temperature move at 1,342 feet per second, about as fast as a partly-spent bullet. If the gas is cooled down the molecules lose their energy and travel more and more slowly, until at some temperature they no longer can escape each other's attraction; the gas then changes into a liquid and is said to *condense*.

These countless millions of high-speed molecules are continually striking against the walls of any vessel that contains a gas. Each molecule gives the wall a kick as it hits it and bounces back, and the sum total of the kicks is the pressure of the gas. Clearly the number of kicks will become greater as the number of molecules is greater; also the faster the molecules move the harder they will hit. So for any fixed quantity of gas the pressure (P) will increase as the temperature (T) is increased and as the volume (V) is decreased. We express this by the formula:—

$$\frac{PV}{T} = R$$

where R is a fixed number which depends on the quantity of gas and the units used for measuring the pressure, volume and temperature. We can express this by two laws:—

(1) *Boyle's law.* The volume of a gas at constant temperature varies inversely as the pressure.

(2) *Charles's law.* The volume of a gas at constant pressure is proportional to the "absolute temperature," which is the temperature in Centigrade degrees counted from the point of no heat, i.e. —273 deg. C., instead of from 0 deg. C., the melting point of ice.

These are best explained by Figs. 15 and 16. Boyle's law therefore expresses the springiness of a gas. It is for this property that air is used to fill motor tyres and air cushions: it is the perfect spring, never losing its elasticity and strength. Charles's

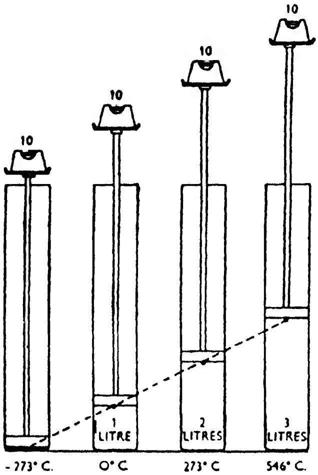


Fig. 16. *Model illustrating Charles's law. The volume of a gas increases regularly as the temperature rises.*

law expresses the great expansion of a gas by heat: this is used in certain types of thermometers, and is the cause of all the movements of air that, as wind and weather, affect every living thing on earth.

Boyle's law and Charles's law apply to all gases and only to gases. A gas is nearly all empty space, and the molecules in it take up so little of its bulk, that their individual attractions have hardly any effect on each other under ordinary conditions; so normally the differences between the molecules do not matter and all gases are equally expansible by heat and equally compressible. If, however, gases are so highly compressed that the molecules are forced to come very close to each other, their attractions come into play and Boyle's and Charles's laws do not hold good. These laws, in fact, are never exactly true, but the hotter the gas and the less its pressure the more nearly true they become, that is to say, the more closely do they describe what in fact occurs.

Liquids

In the liquid state the molecules are within the range of each other's attraction, but they are not held in any fixed position. Consequently a liquid resembles a gas in that it flows, but differs from it in having a free surface.

The flow of liquids and gases is extremely important in industry. When a liquid or gas is moved through a tube, currents and eddies are always set up: these then die down through friction. The result is that some of the energy of motion of the fluid as a whole is converted into the energy of the motion of the eddies, which in turn becomes low-grade heat, and is wasted. The same thing occurs when a ship is moved through water or a plane through air: a great part of the work of the engines is wasted in heating the sea or air. Engineers are always alert to prevent these eddies and in the case of objects moving through water, they are minimized by giving the objects a streamline form, the shape of a fish, with blunt head and tapered tail. The most perfect examples are seen in the design of high-speed aeroplanes (see Fig. 17).

The most interesting properties of liquids are connected with their surfaces. A liquid behaves as if its free surface was a thin elastic skin. Why does a drop hang on the open end of a tap before it drops? What holds it up? All the molecules of the surface are attracting each other sideways and being attracted inward, but nothing is attracting

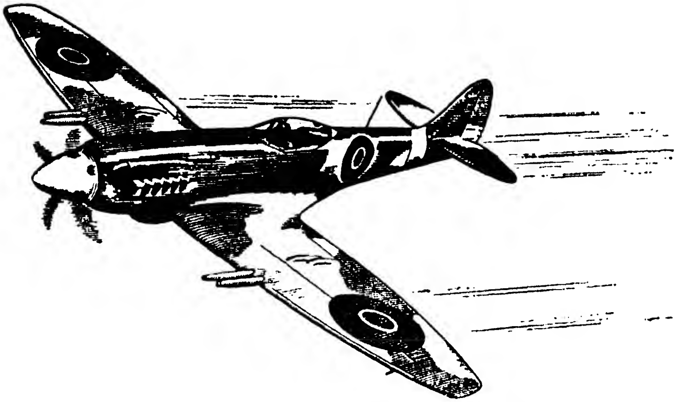


Fig. 17. *Model of a modern aeroplane to show the streamlined design. This is incorporated solely for the purpose of minimizing any loss of speed due to the formation of eddies which convert its energy of motion into low-grade heat. Ships and cars are sometimes streamlined for a similar reason.*

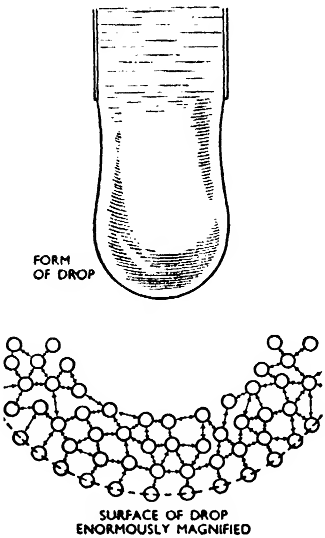


Fig. 18. *Form taken by a drop of water (above) with its surface (below) magnified to show how the molecules attract each other.*

them outward (see Fig. 18). So the total attraction, upward and inward, has the effect of an elastic skin and is called surface tension: this is enough to support the weight of the drop.

Every liquid, then, has a surface which is always stretched and so is always tending to contract as much as possible and so to form the figure with the smallest surface, a sphere. Water sprinkled on a surface it does not wet—that is one which is waxy or dusty—forms more or less flattened, spherical drops; other surfaces (such as clean glass) attract water so strongly that they overcome its surface tension and spread it into a thin film.

The attraction of surfaces that are wetted for the liquid that wets them is the cause of capillarity, the rising of liquids in fine tubes. If you dip a narrow glass tube, such as a thermometer tube, in water, the water rises in it, for perhaps half an inch. If you dip it into

mercury, which does not wet glass, the opposite effect occurs, and the mercury will not rise in the tube as far as the liquid level (see Fig. 19). Certain porous substances such as cloth, paper, sand, salt, etc., may be thought of as a mass of fine crevices and water rises in these for the same reason as in fine tubes. Thus water or oil will rise up a cotton wick, but mercury will not, because it does not wet—that is, it is not attracted by—cotton fibre.

Surface tension accounts for the formation of films of liquids, as in bubbles. The shape of a bubble is due to the surface tension, which makes the surface as small as possible. A free bubble is therefore a

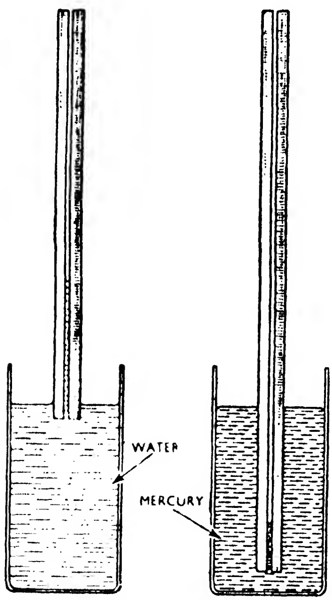


Fig. 19. *Diagram showing the difference between a liquid which wets the side of a fine glass tube and mercury which does not.*

sphere. A foam or froth is a mass of bubbles, each of which consists of two liquid skins, enclosing a very little liquid. The shapes of bubbles in foams are not spheres but beautiful and complicated geometrical forms which result from the pull of the films, which tend to make the figure with the smallest surface that will enclose the air.

Foams are useful for washing purposes. The surface films have an inward attraction; so any particles of dirt that can be wetted are attracted and held by the surfaces: thus foams have cleansing power. Soaps not only foam, but also lower the surface tension of water, so that dirt is wetted much more easily and so made ready to be dragged into the films of the bubbles.

Solids

Solids have a fixed volume for the same reason as liquids, namely that their molecules attract each other: but unlike liquids they have a fixed shape, and this because the molecules are attracted to each other so firmly that they cannot move out of their positions. This is why solids are strong: in order to divide a solid it is necessary to pull the molecules apart. There are several kinds of strength. Great tensile strength (resistance to a pull) is characteristic of metals. These also have compressional strength (resistance to crushing), but this is possessed by several kinds of material—for example stone—which have no great tensile strength. Thus stone can be used for pillars, but not for girders.

Then there is toughness—the ability to bend without breaking; and hardness—the resistance to scratching, that is to the dislodgement of particles. Each of these

qualities correspond to particular arrangements of the molecules of the solid.

The molecules in a solid may have little or no order or arrangement. In glass or flint or glue the molecules seem to lie in every and all directions: a substance of this kind breaks with the peculiar curved fracture that is familiar in flint or toffee. But most solids are masses of crystals, sometimes very small, sometimes large: these can easily be seen in the broken surface of a piece of cast-iron or marble or loaf-sugar, though some solids, such as chalk or charcoal, are made up of crystals too small to be seen.

A crystal is an assemblage of molecules in a repeating pattern or space-lattice. Fig. 20 represents the pattern in which the silver atoms are grouped in silver. A silver spoon would consist of countless silver crystals stuck together, each made up of this pattern repeated for millions of atoms in each direction. Marble has a different pattern, iron a different pattern again. In a single crystal such as a lump of soda or sugar-candy the pattern carries on right through the crystal.

It is not difficult to see that in most crystals there will be layers of atoms lying side by side like the leaves of a book and for this reason crystals are very easily "cleaved" or split along certain lines. This property is used by diamond cutters, who learn to recognize the directions in which diamonds can be cleaved and so save the enormously laborious task of cutting them. On the other hand, cleavage is very undesirable in metals which are required to be tough. So cast metals, which have fairly large crystals, are hammered and rolled to make the crystals smaller and

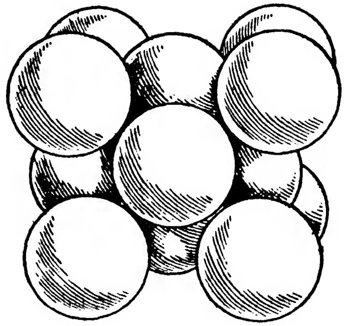


Fig. 20. *The arrangement of atoms in a crystal of silver, more than 100 million times larger than actual size.*

less regular, so diminishing the chance of breakage.

While most solids are crystals or masses of crystals, some consist of a single giant-molecule, that is to say, all the atoms in them are linked together by chemical linkages. Diamonds are of this type, which accounts for their hardness, as also are the thermosetting plastics, such as Bakelite. These plastics start as a powder which consists of moderate-sized molecules. When these are squeezed and heated in a mould they all combine together and form one continuous molecule—a network of carbon, hydrogen and oxygen atoms extending without break from one end of the Bakelite ash-tray or radio-panel, or whatever it may be, to the other.

These plastics differ from the older plastics such as celluloid or rubber, in that they cannot be softened or melted by heat. Melting is the separation of molecules and here there is only one molecule. Plastics of this kind are very strong and light, and very easy to shape into any complicated form for which a mould can be made. Some of

them begin as a liquid which can be poured into a mould and by gentle heating gradually sets into a solid block with the form of the mould.

Change of State

That substances change from one state, solid, liquid or gaseous, to another is very familiar, and these changes are brought about chiefly by changes of temperature, though pressure also has its effect. Some special words are used in this connexion. Thus a solid is said to melt or fuse to a liquid; a liquid or a solid evaporates to a gas. A gas condenses to a liquid or solid, and a liquid freezes to a solid. As molecules attract each other energy is needed, and work has to be done, in order to separate them: so remembering how the molecules are situated in solids, liquids and gases, it is evident that we must use energy for the changes solid→liquid→gas, but that energy will be given out by the changes gas→liquid→solid. So if we heat a mass of broken ice in a saucepan over the gas-ring and take its temperature with a thermometer, we find that it stays at 0 deg. C. all the time the ice is melting: only then does the temperature of the water begin to rise. So also, once the water boils it stays at 100 deg. C. until it has all been turned into steam. All the while heat-energy is flowing in from the gas-flame, but while the ice is melting or the water is boiling the only change that results is a change of state: so we suppose that the heat that is entering the pan is used up in changing ice to water or water to steam.

When a pound of liquid is turned into a pound of gas, it increases vastly in bulk: thus a gallon of water produces over 200 cubic feet of steam. To increase in bulk it has to do more work, for it has to push away the air that is pressing on it. Consequently the pressure on a liquid affects its boiling point.

The water in a high-pressure steam boiler may reach 330 deg. C., about as hot as melting lead, before it can boil. On the other hand at the top of a mountain where pressure is very low, water boils at a lower temperature than usual, and indeed it is impossible to boil an egg or a potato at the top of a high mountain unless a closed pressure-cooker is used. There are, however, limits to the alteration of boiling point. Thus cold water will not boil, in the usual sense of bubbling, even in the highest vacuum; and the highest pressure will not stop water from turning into a gas when its temperature reaches 374 deg. C.

Every liquid has a temperature above which it cannot remain as such whatever the pressure, and this is called the critical temperature. The oxygen and nitrogen of the air are normally far above their critical temperatures (−118° C. and −146° C.) so no amount of compression can change air into a liquid, and in order to liquefy air, it has first to be cooled below −140 deg. C. Carbon dioxide, on the other hand, has a critical temperature of 31·1 deg. C., so mere compression is enough to liquefy it. Many gases are most easily stored in iron cylinders, in the form of liquids at high pressures.

Evaporation and condensation are the causes of rain, dew, fog, snow, hail and frost. When a liquid (or a solid) that will evaporate is put in a closed space, a bottle for example, it begins to evaporate. As soon as vapour is formed it begins to condense; this continues until the vapour is being produced

as fast as it condenses, and at any given temperature, this occurs when the vapour has a certain fixed pressure called the vapour pressure. The sea and other water continually evaporates into the air, and this rises into upper and cooler layers of the atmosphere.

Now the cooler water becomes the lower is its vapour pressure, so the warm moist air over the sea when it rises to the upper regions condenses to clouds, vast assemblages of tiny droplets of water. These may increase in size and form rain or, if the weather is very cold, the vapour may condense direct to snow instead of water.

If warm moist air comes in contact with something cold, the water-vapour condenses to droplets of dew. The outside of a glass of iced drink becomes clouded by such. The earth at night radiates heat and so becomes cold, for it receives little or none from the stars. When it becomes cold enough the air in contact with it is cooled below its dew point and dew is deposited on the leaves and so forth. If it is winter, the earth may become so cold that the water vapour changes straight to ice: this is called frost. All the water is moved from the sea to the hills by evaporation and condensation, and it is thus that the Sun raises the water which in its downflow can drive the waterwheels that give us such enormous quantities of electric power, heat and light.

Steam as a Source of Power

Steam gives us an excellent way of moving heat about and of turning heat into work. Steam-radiators are often used—especially on the Continent and in the United States—for heating buildings, and in many United States towns steam-mains are laid in the street, so that houses may buy steam and need not make it. The central boiler, very scientifically and economically fired, uses the heat of its fuel to heat up water and turns it into steam. In the radiator the steam condenses and gives out the heat which the furnace puts into the boiler.

Steam is a very convenient means of boiling water or any solution, such as the dye in a vat. The steam is led in as fast as is possible or desirable, and all the heat which was used to turn the cold water in the boiler into steam is given out to the liquid.

The steam-engine is a means of turning heat into work. Steam-engines run our railways and almost all electrical machinery in Great Britain is in fact operated by steam, because it is the steam-engine that gives the energy that turns the dynamo, the electricity from which gives us light, heat and power.

The heat-energy of steam is nothing else but the movement of molecules, and the steam-engine is designed to make their movement move the blades of a turbine, or a piston in a cylinder. The furnace and boiler are so designed as to cause as much heat as possible to enter the water, and as little as possible to go up the chimney: so the comparatively cool gases leaving the furnace are made to heat the water which is later to be run into the boiler.

The steam is generated at very high pressure, for we want the expansion of the steam to be done usefully in the turbine or cylinder, and not uselessly in the boiler. To get the greatest amount of energy from the steam we must slow the molecules down as much as possible, that is, cool the steam as much as we

can before it condenses. Cooling is ensured by allowing the steam to expand to a very large bulk, for which, according to Boyle's law, it must be at a very low pressure. This is ensured by having a very large low-pressure cylinder or turbine and condensing the steam in a thoroughly cold condenser.

Even with all these precautions the steam-engine is very inefficient. No steam-engine turns as much as a quarter of the heat in the coal into useful work, but as there is no better way of getting work from coal we have to make do with it.

This loss of from three-quarters to five-sixths of the energy is not a matter of bad design, but necessarily follows from the nature of heat-engines. One-hundred-per-cent efficiency can never be reached: but the hotter the working substance (such as steam) reaches the engine and the colder it leaves it, the greater is the proportion of heat that can be turned into useful work. But an upper limit to the temperature at which a machine can be worked is set by the loss of strength of metals and the difficulties of lubrication at very high temperatures. Petrol engines or oil engines do better and may turn one-third of the heat into work. This is because so high a temperature is reached by the gases in their cylinders.

The human muscle is probably more efficient than any engine. It burns the glucose in the blood and is thought to turn about 40 per cent of the resulting energy into work, and only about 60 per cent into heat.

Change of State: Solid and Liquid

When a pure solid is heated, it usually remains hard up to a certain temperature, at which it melts completely to a perfect liquid. Thus ice remains hard up to 0 deg. C. and liquefies completely to water before it becomes any hotter. When the liquid is cooled and stirred, just the opposite effect occurs at the same temperature. Thus, the freezing point and melting point of a substance are the same: water freezes at 0 deg. C., and ice melts at 0 deg. C. There is, however, a difference between the two cases. Ice cannot, at normal pressures, be heated above 0 deg. C., but water, if kept still and out of contact with any ice, can be cooled several degrees below 0 deg. C. It is then said to be *supercooled.*

If water is cooled to, say, −5 deg. C. in this way, it may remain liquid indefinitely, but if it is strongly stirred or if it touches ice it instantly solidifies. Sometimes a mist of supercooled water droplets is formed in the air. When such a mist drifts against leaves or anything on which there is frost or ice, it solidifies on them forming a thick coating of glassy ice, the so-called glass-thaw. This heavy brittle coating may do enormous damage to trees.

Freezing and melting are of the greatest use for the process of casting, the making of various objects by pouring melted metals into moulds of sand, or sometimes of iron. Some metals expand when they solidify (type metal and cast iron are examples) and so give very clear impressions of the mould, but most of them contract. Casting is very little used for anything else but metal and glass, for most other materials are destroyed or altered by an attempt to melt them.

Pure substances, like ice or copper, melt and freeze sharply at a single temperature; but mixtures of

several substances gradually soften as they become warmer. Thus butter, a mixture of many fats, breaks with a crystalline fracture, like loaf sugar, at Arctic temperatures; but as it warms up, it gradually softens till it finally melts to a clear liquid.

Substances which do not form true crystals have generally no real melting point at all. Thus, glass, when heated, gradually becomes soft and pliable, then becomes treacly, and finally, when hot enough, a thin liquid; but it is impossible to name any temperature as the melting point of glass. The same is true of volcanic lava, of pitch or toffee. This gradual softening allows glass to be worked in a unique way, by blowing. Great skill is needed, but the products are much superior in strength and beauty to those made by casting.

Water, the commonest of liquids, is very unusual in its behaviour. When water freezes an exceptional amount of heat is given out. Moreover, water, when cooled, contracts like other liquids as far as 4 deg. C.; but, when cooled from 4 deg. C to 0 deg. C., water does not contract like other liquids, but expands; and when it freezes it further expands considerably—by about a tenth of its bulk. Consequently, ice is lighter than and floats upon water. So when a pond or lake in winter cools below 4 deg. C., the coldest water is the lightest and it floats, covering the less cold water at 4 deg. C. The cold surface layer freezes and the ice floats, forming a further protective covering. Consequently, it is rare for any but a very shallow pond to freeze solid. If water had not these peculiar properties, water-dwelling animals and plants would have required the power to resist prolonged freezing in solid ice and the aquatic flora and fauna of cold countries would have been widely different from the forms we know.

Electricity and Magnetism

Much of our study of physics will be concerned with radiation, the transmission of energy by electromagnetic waves: it is fitting, therefore, that we should make a little study of electricity and magnetism before it.

The first thing that is obvious about electricity and magnetism is that electrified or magnetized bodies attract or repel others. A piece of vulcanite or sealing-wax, after rubbing with a woollen cloth, repels another rubbed piece. The north pole of a magnet attracts iron or the south pole of another magnet, while it repels the north pole of another magnet. All attractions and repulsions (all forces, in fact, in the Universe) are either electrical, magnetic or gravitational. We therefore take as a basic fact of science the following:—

1. Like electrical charges (both positive or both negative) repel each other. Unlike electrical charges attract each other.
2. Like poles of a magnet repel each other. Unlike poles of a magnet attract each other.
3. All bodies attract each other gravitationally.

We cannot explain how the rubbed amber attracts the paper or the magnet the iron, nor how the Earth attracts the Moon: these are basic principles that have to be taken for granted: if we could explain them, we could only do so in terms that required still further explanation. Whatever we say, there is always another question to ask.

All electricity is the same,

whether it is obtained from rubbing sealing-wax, from the clouds in a lightning flash, from a torch-battery or a dynamo. The electricity that moves about conductors consists of countless particles called electrons, far smaller and lighter than atoms and capable of moving in between the atoms of certain bodies. As these electrons have like and equal electrical charges, which we call a negative charge, they all repel each other; consequently, electricity spreads itself all over any conductor. Positive electricity consists of protons which are much heavier particles and do not travel through conductors. The atoms of matter (page 32) contain protons in their nuclei and an equal number of electrons in their outer portions. So, as a whole, atoms are neither negatively nor positively electrified; but if some negative electricity (that is a few electrons) can be obtained from any kind of atom, then the residue of the atom is left with a positive charge bigger than its negative charge and so we say it is positively charged.

The simplest way of obtaining electricity is from the atoms of a metal (see Fig. 21). When two metals are connected by a conducting wire and immersed in a solution which acts chemically on one of them, such as a dilute acid, then electrons leave the atoms of the metal which reacts most easily, and travel through the wire to the other metal. The atoms turn into positively charged ions which dissolve in the acid. There are many kinds of batteries, but all of them have the disadvantage of being very expensive ways of making electricity, because in effect they burn metal to make it; which is much more expensive than burning coal even in an inefficient steam-engine, and using this to drive a dynamo (page 53).

The lead accumulator can be recharged by passing an electric current through it in the reverse direction, but the Daniell, bichromate and Leclanché cells are finished when the zinc or the chemical reagent is used up.

It is a familiar fact that electrical conductors are made of metal. Metals have a few free electrons which pass very easily from atom to atom and they are far better conductors than anything else. Carbon (graphite, gas carbon, charcoal) is a fair conductor as are solutions of acids, alkalis and salts, but the great majority of substances pass electricity only with great difficulty, if at all. The electrons are real particles moving through the

ELECTRIC BATTERIES

(The sign ⁝ indicates a porous partition)

	Negative pole	*Chemical reagents*	*Positive pole*
Daniell cell .	ZINC	dilute sulphuric acid ⁝ copper sulphate	COPPER
Bichromate cell	ZINC	dilute sulphuric acid + potassium bichromate	CARBON
Leclanché cell	ZINC	ammonium chloride + manganese dioxide	CARBON
Lead accumulator	LEAD	dilute sulphuric acid	LEAD PEROXIDE

wire, so naturally, they behave very like water moving through a pipe. Thus, the pressure which drives water through a pipe is represented by the voltage (electromotive force, e.m.f.) which drives the electron through the wire. The quantity of electricity that moves per second, is the current (this is measured in amperes). The resistance is the opposition to the flow of the current and it depends on the narrowness, length, and the material of the wire; it is measured in ohms. A valuable rule can be expressed by:—

(current in amps) $\times$ (resistance in ohms) $=$ e.m.f. in volts.

Thus, if you require to know the resistance of a wire which will pass 5 amp. on a 200-volt circuit

$$5 \times \text{resistance} = 200$$

and resistance $=$ 40 ohms.

The moving electrons have energy and when they are forced through a conductor some of this energy appears as heat. The heat given out per second depends on the square of the current and the resistance of the conductor. Ordinary electric wires have a very low resistance and so hardly get hot at all, but for the elements of electric stoves or the filaments of lamps, wires of a high resistance are used in order that heat may be evolved.

So far flowing electricity has been shown to behave very much like flowing water (see Fig. 22), but a current of electrons has a special property, in that it produces a magnetic force.

Magnets and Electricity

The natural magnetic iron ore (loadstone) and the steel magnet were known long before the magnetic effects of electricity were discovered. Everything is very slightly attracted or repelled by the magnet,

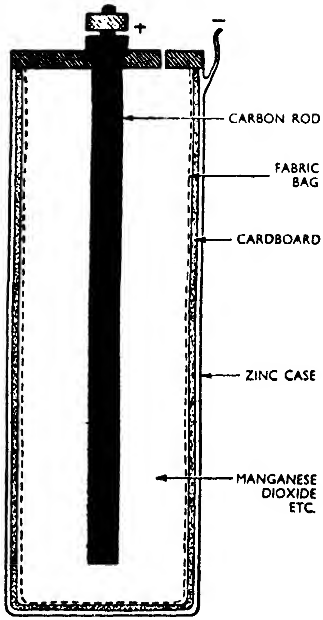


Fig. 21. *Section of a dry cell (Leclanché type) to show its fundamental component parts.*

but three of the metals, cobalt, nickel and especially iron (and its alloy, steel) are very powerfully attracted. Iron is exceptional, in that it can be made into a magnet. The Earth is a magnet—nobody knows why—with its poles near, but not at, the North and South geographical Poles. So any magnet is attracted by these and if freely suspended or pivoted sets itself north and south. A suspended magnet is a magnetic compass. If a wire be laid over a compass needle and a current passed through it the magnet will move so as to bring itself at right angles to the wire. Thus, an electric current will make

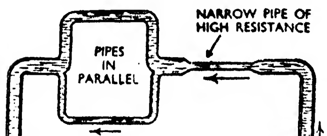
a magnet move, and a magnet when it moves near a conductor makes an electric current. This is the basis of the electromagnet, the motor and the dynamo.

The magnetic force depends on the current: that of a single wire is very small, but by coiling the wire so that all the turns of the coil act in the same way, it may be increased (see Fig. 23), though not indefinitely because an increase of the length of the wire increases the resistance and so decreases the current.

Electromagnets are used in a great variety of electrical apparatus: they consist of a core of pure soft iron, often a bundle of wires, round which is coiled a large number of turns of insulated copper wire. When the current is switched on, the iron becomes a magnet, and when the current is switched off the iron ceases to be a magnet.

Large electromagnets are often suspended from cranes and used for picking up heavy masses of iron, and they are especially useful for handling awkwardly-shaped and dangerous loads, such as sharp-edged steel scrap. The magnet is lowered so as to touch the load and the current is then switched on. The iron core becomes a magnet and attracts the load. When the crane has moved it to its destination, the current is switched off, the iron core ceases to be magnetized and the load drops.

Powerful electromagnets are used to operate the brakes of tramcars. A most valuable use is for removing particles of steel which may become embedded in the eye. A very large



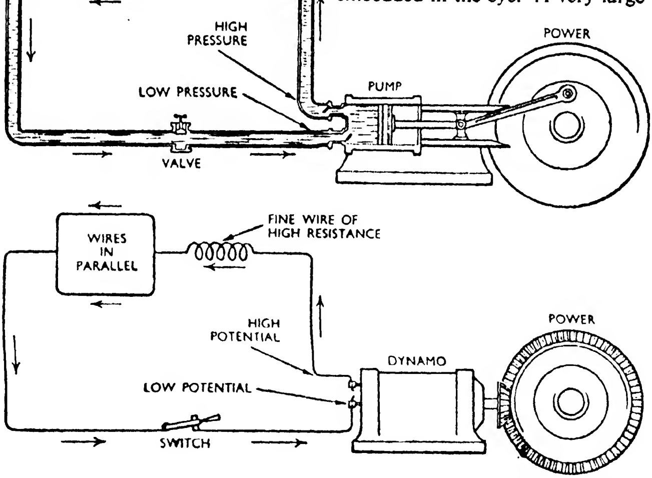


Fig. 22. *Comparison between the behaviour of water flowing in pipes (above) and the behaviour of electricity flowing through wires (below).*

electromagnet with a pointed iron core is brought up to the eye and draws out the steel, which could not have been removed by means of forceps, etc., without further damage to the eyeball. The most important uses of electromagnets are, however, in the reproduction of sound.

Telegraphs and Telephones

As soon as electricity could be made in any quantity, it was realized that by its aid something previously impossible could be done, namely, the almost instantaneous transmission of a signal to as great a distance as a wire would carry the current. It was easy to send the signal by making and breaking the circuit, but in the early days of current electricity it was not easy to register the signal at the other end.

The invention of the electromagnet made this easier. The telegraph in its simplest form is a single wire connected at each end to the Earth, which acts as a conductor. A number of Daniell cells provide the current and this is switched on and off by a tapping key, either for a very short period, a dot, or for a longer period, a dash; at the receiving end is an electromagnet which attracts an armature, and so produces a series of clicks which the telegraphist can read. Alternatively, a compass needle may be deflected back and forth, a buzzer energized or a light lit up. For long-distance telegraphy by oceanic cable the receiving of signals becomes more difficult owing to the great length of the conductor and the weakness of the currents, and the electromagnet is employed to move an ink-jet so as to mark a moving paper ribbon with dots and dashes.

The telegraph has been largely

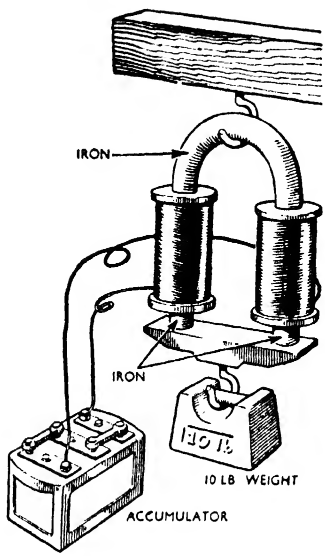


Fig. 23. *Model of an electromagnet supporting a 10-lb. weight.*

replaced by the telephone which does not require of its users the special training of the telegraphist. The modern telephone mouthpiece and receiver are simple enough, the complicated arrangements which cannot here be described are those by which any subscriber can be connected to any other.

Sound and the Telephone

Sound consists of waves, not up-and down-waves such as those on the surface of water, but a series of pulses of compressed and rarefied air travelling at about 1,000 ft. per second (see Fig. 24). Thus, any body, which is exposed to sound, in this case the diaphragm of a telephone mouthpiece, receives every second some hundreds of pushes

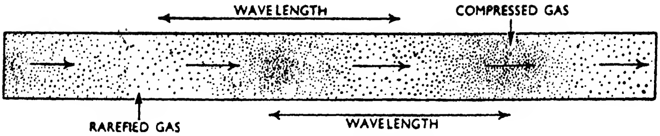


Fig. 24. *Diagram indicating the manner in which the molecules of air are alternately compressed and rarefied in a sound wave.*

from each of the compression waves and some hundreds of pulls from each of the waves of rarefaction. So sound sets any flat movable body vibrating in time with its waves.

When the diaphragm vibrates in front of the magnet it compresses fine grains of carbon and the power of the carbon to conduct electricity increases and decreases in time with each vibration (see Fig. 25). But an increase or decrease of the power of the carbon to conduct causes a proportionate change in the current it carries, so the current that flows through the whole circuit alters in time with the sound waves. This current travels to the receiver.

As the current varies in time with the vibrations of the speaker's voice, so the magnetic force of this electromagnet alters, and the iron plate is pulled in and out in time with the varying magnetic force. The plate sets the air vibrating in time with the vibrations that were made by the speaker's voice, and so reproduces it. Loud-speakers, and indeed all electrical contrivances for reproducing sound, work on some such principle.

The Dynamo, Motor and Transformer

The dynamo is intended to turn energy of motion into electrical energy. By its aid we can turn the chemical energy of coal and oxygen or the radiant energy of the Sun (which raises water from the sea to the top of a waterfall) into electrical energy. The dynamo gave us the first means of providing electrical energy at a cost comparable with other energy, and so ushered in the electrical age. The electrical energy made by the dynamo at the power station is turned into light by filament and gas-discharge lamps,

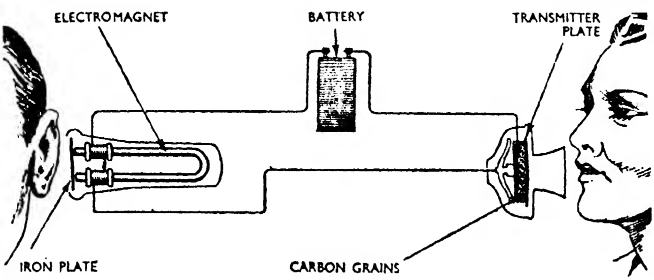


Fig. 25. *Principle of the telephone showing the connexions between the transmitter plate and the electromagnet at the receiving end, via the battery which supplies the current for the sound impulse.*

into heat by electric fires and cookers, and into motion by electric motors.

Dynamos are quite complicated in construction and here we can learn only the principles on which they work. If a compass needle is brought near a magnet, its north pole is repelled by the north pole of the magnet and attracted by the south pole. These two attractions together cause it to move in a particular direction at each place. We can draw lines round the magnet so that a north pole would move along these lines. These lines show the direction of the field of magnetic force and we call them lines of force. Fig. 26 shows the lines of force round a horseshoe magnet.

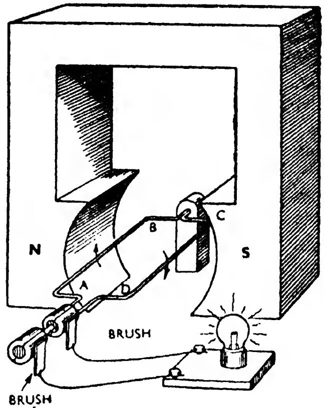


Fig. 27. *Diagram illustrating the principle of the A.C. dynamo.*

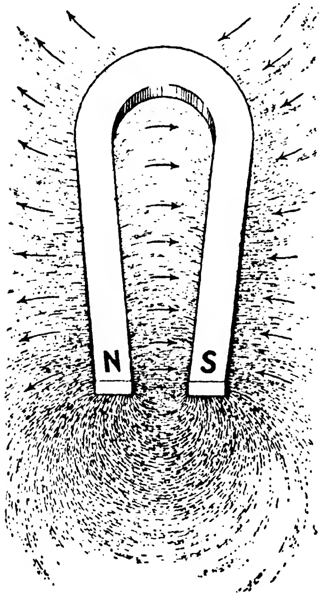


Fig. 26. *Lines of force round a horseshoe magnet as indicated by the disposition of iron filings.*

The epoch-making discovery which started the age of electricity was made by Faraday in 1831, when he found that if a wire moves so as to cut the lines of force of a magnetic field a current is generated in the wire. Thus, as a wire loop is made to cross the face of the pole of a magnet a current flows in it. In the dynamo a great number of wires are made to rotate through the field of a powerful magnet, and the effect of all of them together is to produce a considerable current at a high voltage, and all our electric supply is produced in this way.

The alternator is the simplest kind of dynamo. The principle of it is illustrated in Fig. 27. Suppose we have a powerful magnet, NS, and in the space between its poles we have a wire loop, ABCD, which can be rotated about a shaft. A and D are connected to insulated slip rings from which brushes take off the current.

Suppose CD is moving down and

AB is moving up. Both of these wires are cutting lines of force which stretch from N to S, so the current flows, let us say, in the direction ABCD. When the loop is vertical, current will cease to flow, because no lines of force are being cut. As it moves on, AB will take the place which CD had and CD will take the place of AB, so the current will now be in the direction DCBA. So the effect of this dynamo will be to give an alternating current, the direction of which is reversed every half-revolution of the shaft.

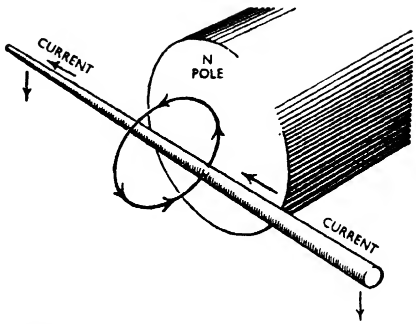


Fig. 29. *Diagram showing how a wire carrying a permanent current is moved by a magnet.*

An alternating current is just as convenient as direct for almost all purposes, and much more convenient for some, as it is very easily transformed to higher or lower voltage.

If direct current (not alternating) is wanted, a commutator is employed, and the wires, AB, CD, are connected to each side of a split ring. It is clear that the brush (b)(see Fig. 28), always takes current from the side of the loop which is passing the north pole, and so current always passes through it in the same direction, though this current increases and diminishes according to the position of the loop.

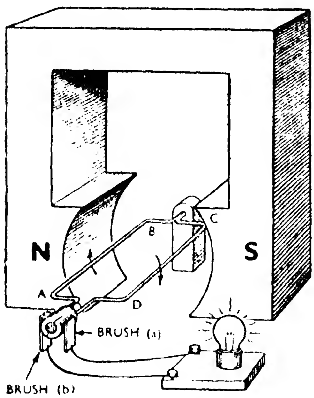


Fig. 28. *Diagram illustrating the principle of the D.C. dynamo.*

To make this simple dynamo into a practical machine:—

1. We increase the number of wire loops by using a coil instead of a single loop.
2. We wind the coil on an iron core. This tends to concentrate the magnetic field round the coil.
3. Instead of a permanent magnet we use a powerful electromagnet energized by the current the dynamo itself makes.

Dynamos can be used as motors if current (of the right type) is passed through the coils. It will be remembered that a wire had round it a magnetic field such as tends to make a magnet pole go round it. So if a wire carrying a current is in front of a north magnet

pole (see Fig. 29), it will tend to move the magnet pole in the direction of the arrow. If the magnet pole is fixed, the wire moves instead but, of course, in the opposite direction. So if a battery is substituted for the lamp and a current is passed through the direct current dynamo (see Fig. 28), the loop will turn and the dynamo will act as a motor.

Transmitting Current

The alternator will also act as a motor provided that it is supplied with alternating current and that it runs at exactly the same speed as the dynamo which made the alternating current. Such a motor can work only if it makes one half revolution each time the alternating current reverses. The alternating current on the grid system of supply is very exactly timed. Electric clocks keep perfect time because they are run by these synchronous motors from the perfectly timed alternating current of the grid.

It is convenient to generate electricity at large stations where power is cheap and to transmit it long distances to the places where it is consumed. Now a current always generates heat when it passes through a conductor and the heat is waste of energy. The quantity of heat generated depends on the square of the current. It therefore pays to send as little current as possible. Now the power depends on *voltage* × *current*. So if we want to send a supply of 1,000,000 watts to a town, we may send 10,000 amperes at 100 volts or 10 amperes at 100,000 volts. The first method will waste a million times more current as heat than would the other. But we cannot supply electricity to houses at a greater voltage

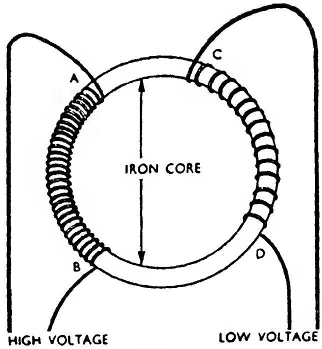


Fig. 30. *Diagram showing the principle of the transformer for alternating current.*

than 230 volts, owing to the danger of electric shock. So the practice is to send electricity at a high voltage and step it down to a low voltage by one or more transformers.

The Transformer

The transformers used for alternating current are quite simple in principle. The essential idea of them is that of two coils, AB and CD (see Fig. 30), wound on a single iron core. As the current alternates in one of these coils, say AB, the iron core is alternately magnetized and de-magnetized. The change in the magnetic field of the iron core causes currents to be induced in the other coil. Now the voltage of the current depends on the number of turns in the coil. If the current is put in through the coil AB which has many turns and taken off through the coil CD with few turns, the voltage is reduced; if the current is put in through the short coil and taken off from the long, the voltage is increased. The quantity of energy remains the same except for a small loss (from $\frac{1}{200}$ to $\frac{1}{25}$ of the

whole). This energy is converted into heat, so cores of large transformers usually have to be cooled.

Radiation

There are a large number of kinds of energy which can travel through empty space — a vacuum — and which carry no matter with them. The one that we know best is light. When light comes from the Sun nothing seems to arrive except energy. The light will do work (page 26): it does not consist of particles of anything that we can weigh or collect, and it certainly consists of waves of some kind. Thus two beams of light travelling in one direction can cancel out and produce darkness: two streams of particles could not cancel out in this way, but two sets of waves can, for the peaks of one set may coincide with and fill the troughs of the other set. But if light consists of waves, what is it that is made wavy? We used to talk of a luminiferous ether that vibrated when light passed through it, but the idea produced so many difficulties and inconsistencies that science, today, does not worry itself about the medium through which light moves and is content to chronicle how it moves.

Among the different kinds of energy which we class as radiation are radio waves, infra-red radiation, light, ultra-violet rays, and X-rays. They are obviously extremely different and the difference between them arises from their different wavelength and frequency. It is difficult, impossible indeed, to picture electromagnetic waves, but wavelength and frequency can be easily understood by thinking about water waves which we have all seen.

Suppose you stand on the end of a pier and watch the waves coming in from the sea. Suppose twelve wave crests pass you every minute and the crests are 20 ft. apart. Then the frequency of the waves is 12 per minute or 0·2 per second and the wavelength (see Fig. 31) the distance between similar parts of two successive waves, is 20 ft. The velocity of the waves must be $12 \times 20 = 240$ ft. per minute. So for any kind of waves, whether of water, sound or radiation: *frequency* × *wavelength* = *velocity*.

Radiation has been proved to consist of electromagnetic waves, and these we cannot possibly picture, because there is nothing there to see, as there is in water waves. Corresponding to each crest we must imagine a region where there is a magnetic force such as there is near the pole of a magnet and corresponding to each trough a region of electrical force acting in a direction at right angles to the magnetic force. So if you could imagine yourself watching a stream of radiation going past you and if you were equipped with instruments to detect very swiftly changing magnetic forces you would notice an alternating magnetic field. The number of alternations per second

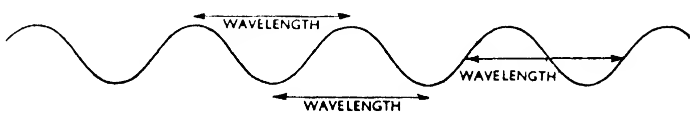


Fig. 31. *Diagram showing the extent of wavelengths measured in three positions. The velocity of waves is determined by wavelength × frequency.*

ELECTROMAGNETIC RADIATIONS

Kind of radiation	*Wavelength in centimetres*	*Made by*	*Used for*
Radio waves .	200,000 to 200	Moving electric charges	Signalling; broadcasting; television
Short Hertzian waves . .	200 to ·02	Moving electric charges	Heating internal parts of the body; radar
Infra-red radiation .	·02 to ·00008	Hot solids	Heat rays; long-range photographs
Light . . .	·00008 to ·00004	Hot solids; electrical discharges in gases	Vision; gives energy to plants; photography, etc.
Ultra-violet radiation .	·00004 to ·0000012	Electrical discharges through gases; sunlight	Special photographs; destruction of bacteria, and other medical uses
X-rays . .	·0000012 to ·00000002	Stream of electrons striking matter	Photography of interior of bodies; treatment of cancer
Gamma radiation .	·00000002 to ·0000000003	Explosion of atoms of radium and similar elements	Treatment of cancer

would be the frequency, and, since light travels 30,000 million cm. per second, the wavelength in centimetres (the distance travelled during an alternation) would be 30,000 million divided by the frequency.

When a magnetic field changes, it produces an electrical field of force, so the wave consists of rapidly changing magnetic and electrical fields of force. All the different kinds of rays which consist of electromagnetic waves are classed as electromagnetic radiation. The table above indicates how these are related to each other. We may compare it to a scale on the piano. As the wavelength of sound gets shorter, the sounds themselves become shriller and shriller; as the wavelength of radiation gets less the rays change from radio waves through heat rays, light, X-rays, to the rays of radium.

The table contains all the useful radiations known, but radiations of even shorter and longer wavelengths exist: we do not know whether there are any higher or lower limits to the wavelength of radiation.

The Making of Light

Light is one of the main necessities of Man and a great many people are concerned with producing and selling the means of making it.

If any heat-resistant solid, such as a piece of coke, is heated, it first gives out invisible heat rays; when its temperature reaches about 500 deg. C., it gives out red light; as it is further heated, the light becomes yellow, then white. As the temperature becomes higher the light

becomes more brilliant, but at any temperature we can reach, nearly all the energy given out by a hot solid is in the form of heat rays.

Why should ordinary matter when heated give out electromagnetic waves? Roughly speaking, because every kind of matter is partly made up of electricity, and the heating of matter makes its atoms move very fast and the motion of the electricity produces changes in electrical fields which produce electromagnetic waves.

Solids and liquids glow far more brightly than gases when they are heated. The blue flame of a gas-ring gives out very little light, yet it is far hotter than molten iron or white-hot coke, which glow brilliantly. The bright flames of a candle or oil or acetylene are bright because they are full of tiny, white-hot particles of solid soot. The temperature of these particles may be 1,500 deg. to 1,700 deg. C. At very much higher temperatures gases glow brilliantly. Thus the Sun, whose surface is gaseous and has a temperature of more than 6,000 deg. C., emits a large proportion of its energy in the form of light. Many stars are much hotter than this; these have a blue-white colour, whereas that of sunlight is white or yellowish white.

When we burn gas or oil to give us light, about 99·8 per cent of its energy is given out in the form of useless heat, and only about 0·2 per cent in the form of light. Electric filament lamps are better in this respect. They may turn about 2·5 per cent of the energy we buy into light and 97·5 per cent into heat, but since a pennyworth of electricity yields a good deal less energy than a pennyworth of gas, there is not so much difference between their lighting efficiency, and if electricity costs more than about threepence a unit, gas is the cheaper illuminant.

Electric Lamps

The electric filament lamp is simply a fine wire through which a current passes, heating it strongly. The higher the temperature it reaches, the greater the proportion of the electrical energy that will appear as useful light and the less that will be given out as useless heat. By passing a sufficient current through it, the filament can be raised to any temperature it will bear. The problem of the manufacturer is to make a filament which will stand very high temperatures without destruction. Today the metal tungsten is always employed for filaments. It does not melt until at the gigantic temperature of 3,400 deg. C., but a filament cannot be made nearly as hot as this, for it would slowly turn into vapours which would condense on the glass and blacken it. The filament is actually heated to about 2,500 deg. C.

The most efficient way of making light is the discharge lamp, in which a high-tension electric current is passed through the vapour of mercury or sodium. These lamps may turn nearly 7 per cent of the energy supplied to them into light; that is to say, they give several times as much light for the money as a filament lamp.

These highly efficient lamps give a light which is deficient in certain rays that are found in white light, and consequently make colours appear abnormal. This makes them unsuitable for any but street lighting. Some excellent daylight lamps, which give nearly white light, have been designed, but these have not

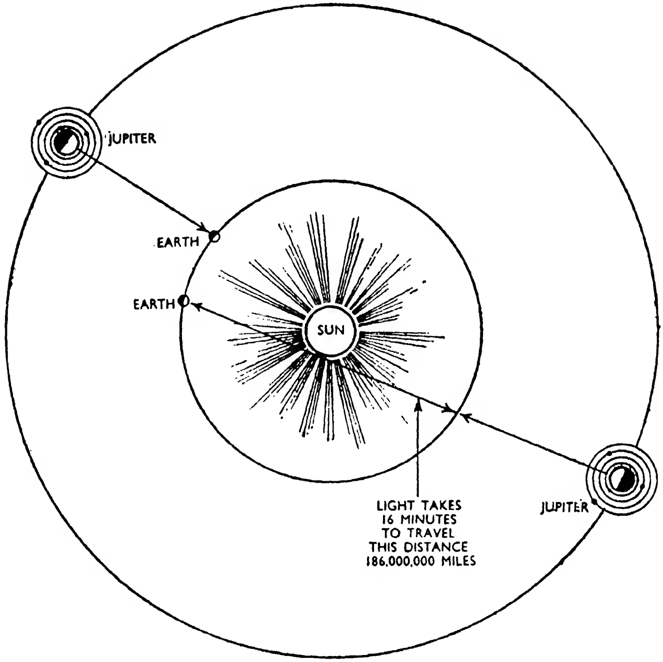


Fig. 32. *Diagram illustrating how the speed of light can be measured by observation of the eclipses of Jupiter's moons. The time that light takes to travel the diameter of the earth's orbit equals 186,000 miles per second.*

the very high efficiency mentioned above.

A few cases are known where light is produced with very little, if any, heat. The firefly and various kinds of bacteria, sometimes seen upon fish or rotten wood, seem to give a cold light. We do not know enough to judge their efficiency.

How Light Travels

Light, like all radiations, moves at the gigantic speed of 186,000 miles per second. This can be measured in various ways: the simplest method is the oldest—by observing the moons of the planet Jupiter. Jupiter travels round the Sun, and the moons travel round Jupiter, at a far steadier rate than any clock, and we can calculate to a second the moment when they should pass behind him and so be eclipsed. Now if we base our calculations on observations made when the Earth is at its nearest to Jupiter, we find that six months later, when the Earth is at its farthest from Jupiter, the satellites seem to be about sixteen minutes late. This sixteen minutes (see Fig. 32) is the time that light takes to

traverse the 186 million miles of the Earth's orbit: a simple division gives its speed. There are many other ways of measuring the speed of light and they all give the same result.

It is well known to everyone that light travels in straight lines—that a light ray does not bend; but this is only true if the light is travelling through a medium (air, water, etc.) which is the same throughout. If, for example, the air is warmer (and therefore more rarefied) below than above, the light rays will be deviated from a straight line. In this way we may see ships beyond the horizon, which if the air were perfectly even in temperature and pressure would be invisible.

The way light is bent when it strikes a polished surface or when it travels from air to glass, as in mirrors, lenses and prisms, is discussed later, but here we will consider the results of the way in which light travels through a uniform transparent medium.

Light does not travel round corners, or does so only to a negligible extent, and so it is intercepted by any opaque object and casts shadows. If we could get light from a single brilliant point shadows would be quite black and their edges almost sharp. But in practice any source of light has a certain size and so we have to consider the course of rays from all the different parts of the source of light from different parts of the object which gives the light. It is easy to see from Fig. 33 that (1) the bigger the light, and (2) the smaller the object, and (3) the farther away the surface on which the shadow falls, the less distinct will the shadow be.

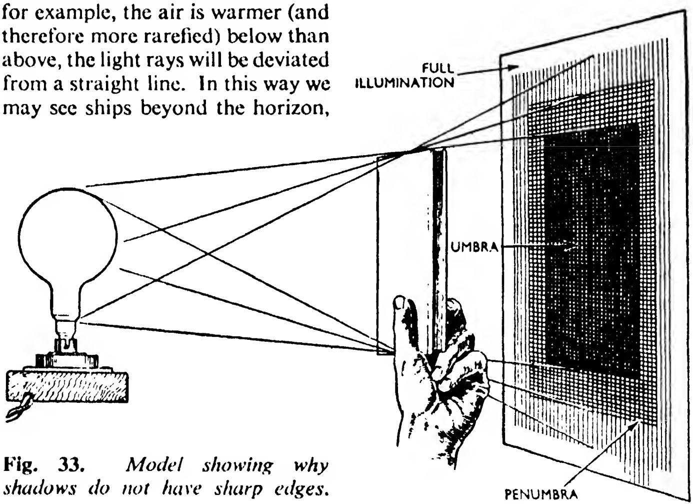


Fig. 33. *Model showing why shadows do not have sharp edges.*

A shadow has two parts, the umbra which receives no light from the source which casts the shadow, and the penumbra, which receives some of the rays from it. The "shadowless" lamps used to illuminate operating tables depend on this principle. The lamp is so large —perhaps two feet in diameter— that wherever the surgeon's head

may be it cannot cut off much of the light, and so it produces no perceptible shadow.

An eclipse of the Moon occurs when the Moon enters the Earth's shadow and an eclipse of the Sun when the Earth enters the Moon's shadow. The Moon is much smaller than the Sun, and so its penumbra is much bigger than its umbra. When the observer is in the penumbra the eclipse appears partial, but in the small umbra it appears total (see Fig. 34).

Reflexion of Light

The fact that we can see objects that do not make light depends on reflexion. If the paper you are looking at did not reflect light it would be invisible. Objects vary very much in their power of reflexion. Even so black a material as soot or black velvet reflects a little light, while nothing reflects quite the whole of the light that falls on it. Polished silver or a good mirror may reflect over 90 per cent.

The rule which tells us the direction light will take when it strikes a mirror is a very simple one. It behaves like a perfectly elastic billiard ball hitting a perfectly elastic cushion. In more exact language, the ray of light which leaves the mirror makes the same angle with a line perpendicular to the mirror as does the ray of light which strikes it (see Fig. 35).

It is a familiar fact that the image seen in a mirror appears to be as far behind it as the object reflected is in front of it. Fig. 36 shows why this is. The rays from the tip of your nose are reflected so that the rays which leave the mirror make the same angle with it as do those which strike it. It is easily seen that the rays from the tip of the nose come to the eye in the same direction as they would have had if they had come from a nose as far behind the glass as the real nose.

A ray of light may be reflected from a number of mirrors successively: but as some light is lost at

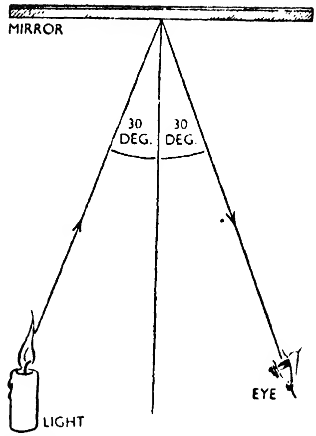


Fig. 35. *Model showing the direction of an image's reflection with the perpendicular in a flat mirror.*

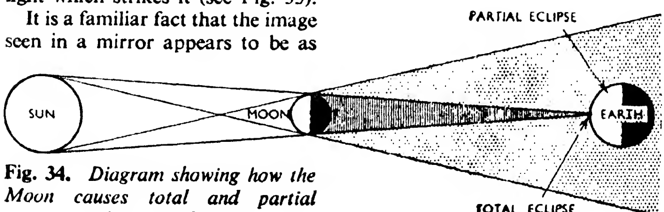


Fig. 34. *Diagram showing how the Moon causes total and partial eclipses of the Sun.*

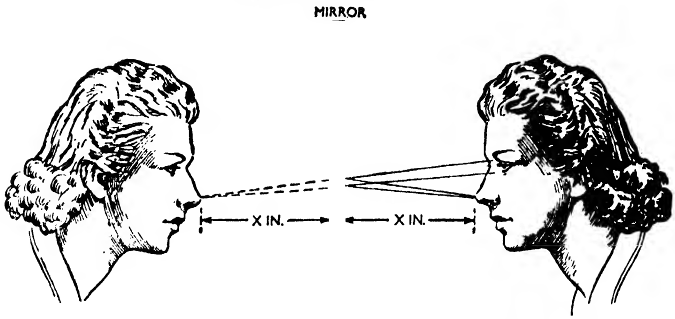


Fig. 36. *Diagram showing why an image appears as far behind a mirror as the object is in front of it.*

each reflexion the number is limited. This is very well seen when one sits between two parallel mirrors at the hairdresser's; the successive reflexions gradually appear fainter and disappear.

Some instruments depend on successive reflexions. The periscope is a good example: the simplest type (see Fig. 37) enables one to see over the head of a crowd: the periscope of a submarine is combined with lenses, so giving a wide field of view. When light is reflected from curved surfaces the same rules are followed, and geometry will tell us what sort of image we shall obtain from a curve of a certain shape. The only case worth studying here is that of convex and concave mirrors whose shape is that of part of a sphere.

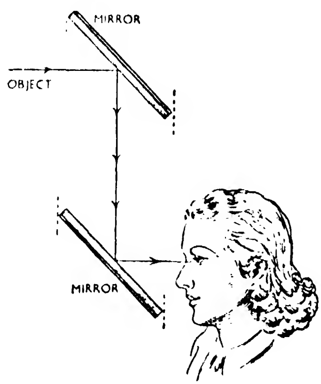


Fig. 37. *Diagram illustrating the principle of the periscope.*

Concave spherical mirrors are used for the reflectors of headlights and the like, though parabolic mirrors are better. They can also be used as efficient burning glasses. Remembering the rule that light is reflected at the same angle with the perpendicular as that at which it strikes the mirror it is easy to see why concave mirrors act as they do (see Fig. 38).

Concave spherical mirrors are also used for magnifying mirrors (e.g. shaving-glasses) and for the largest astronomical telescopes, but it will be easier to understand their action when we have shown something of the action of lenses and the construction of the eye.

Refraction

When a ray of light passes from one transparent material into another, it is slowed up or accelerated

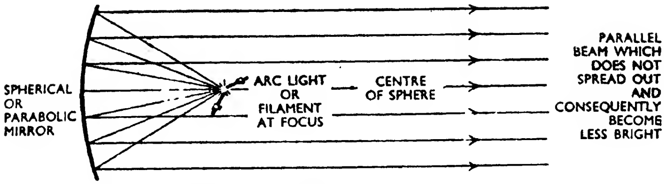


Fig. 38. *Diagram showing how light is reflected from a concave mirror.*

with the result that it is bent through an angle which depends on the materials and on the angle at which the ray strikes the surface. Thus Fig. 39 shows the direction of beams of light entering (*a*) water, (*b*) glass from different angles. When light is bent in this way it is said to be refracted. Very many important effects depend on this, the chief of which is the action of lenses, discussed in the next section. Another effect is the curious way in which water seems to be shallower than it really is, because the rays from any object on the bottom are bent outward and so give the eye the impression of coming from a nearer object. In the same way a stick partly immersed in water appears bent, because the part of it which is under water is made to appear nearer to the eye than it is.

Windows of cut or ridged glass admit light, but cannot be seen through, because the light rays from any object outside are bent in every direction as they meet the different angles of the ridges of the glass.

Light can travel from air into glass or water at any angle, but it cannot travel from water or glass into air at any angle. The rule for finding the direction of a refracted ray is to draw a circle round the point where the ray enters the new material (see Fig. 41). Where the ray cuts the circle draw a line, AB, parallel to EF, the surface of the material. Now draw another line, CD, parallel to AB, so that CD is x times AB. Then AOD will be the course of the ray. The figure x varies according to the materials used: for water and glass it is 1·33.

Now it is not difficult to see that if the ray (say A′O) makes a small enough angle with the surface, the

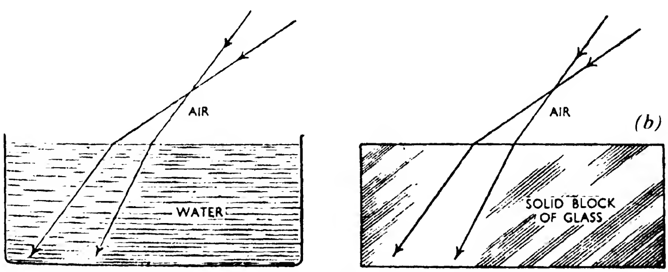


Fig. 39. *Diagram illustrating how light is bent when passing into (a) a tank of water and (b) a solid block of glass.*

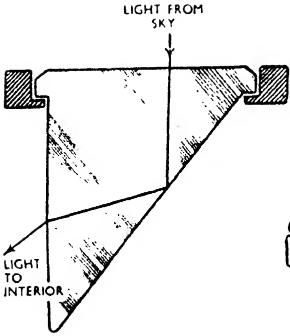


Fig. 40. *Diagram showing how a pavement light reflects the light from the sky into a cellar.*

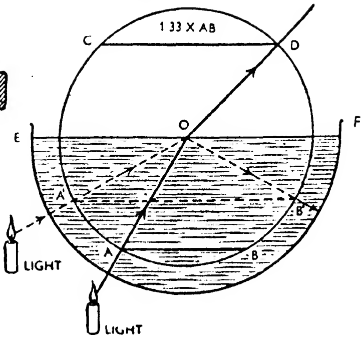


Fig. 41. *Diagram showing how light from a candle is reflected through water to the air.*

line A′B′ becomes so long that we cannot put a line 1·33 times as long in the upper half of the circle. In this case the ray cannot leave the water and is reflected back again (A′OB′).

This is the reason why we find that if we open our eyes under the water of a swimming bath, we often cannot see out of the water. A bubble under water looks brilliant and silvery for the reason that much of the light cannot enter it but is totally reflected from it. A right-angled glass prism for this reason makes an excellent mirror. Such prisms are often used as pavement lights (see Fig. 40) which help to illuminate the interior of a basement by reflecting the light from the sky to the interior.

Optical Instruments

All our common optical instruments, including our own eyes, depend on lenses, or mirrors, or both.

A lens is a piece of glass (or other transparent material), one or both of whose surfaces is a part of a sphere. There are two chief types of lens, the convex, whose centre is thicker than its edges, and the concave, whose edges are thicker than the centre. A convex lens magnifies an object held near it; a concave lens diminishes the object.

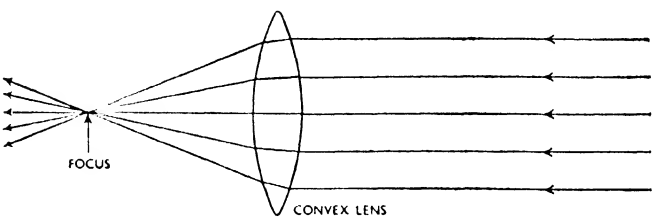
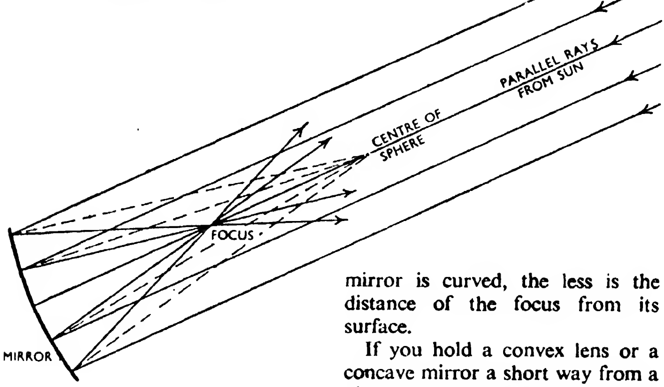


Fig. 42. *Diagram showing how a convex lens brings light to a focus*

Fig. 43. *Diagram showing how a concave mirror brings parallel rays of light to a focus.*



Convex lenses, like concave mirrors, tend to make rays of light converge to a point. If the rays are parallel, as are the rays from a distant object such as the Sun, they are all brought to a point called the focus of the lens (see Fig. 42). If we focus sunlight on a piece of paper with a lens or mirror, the paper is scorched and may catch fire, for all the light-energy which falls on the whole lens is concentrated into this tiny area (see Fig. 43). Heath fires are believed sometimes to be started by a curved piece of broken bottle acting as a lens. The more sharply the lens or mirror is curved, the less is the distance of the focus from its surface.

If you hold a convex lens or a concave mirror a short way from a piece of white paper, you will find that in a certain position it will throw a sharp picture or image of surrounding objects upon it. This is because it focuses all the rays from any one object on to the same part of the paper. Fig. 44 shows clearly that this image must be upside down.

A camera is simply a light-tight box with a lens set in one wall and a sensitive film on the wall opposite. The length of the box can be altered so that the lens shall be at the right distance from the plate to throw a sharp image upon it.

Another almost essential part of the camera is a stop which cuts off

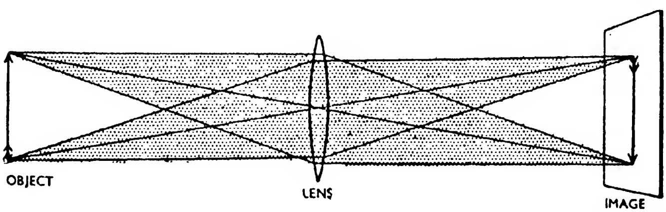


Fig. 44. *Diagram showing how a convex lens casts an image of an object.*

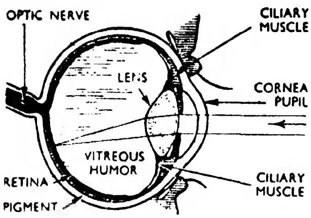


Fig. 45. *Sectional drawing of the human eye to show how images are conveyed to the optic nerve.*

the light from passing through the edges of the lens. A lens can focus with perfect sharpness only at its centre, so the less of the outside we use, the better is the definition. On the other hand, the less of the lens we employ, the less becomes the quantity of light which passes through it and the longer the exposure must be. The shutter stop is therefore usually made adjustable so that a small opening may be used when clear definition is wanted, and a large opening when a short exposure is needed.

The Camera and the Human Eye

The eye is just like a camera in principle. The coloured part, the iris (see Fig. 45), is the stop. Behind this is a lens of jelly-like material which focuses an image of what we see on the retina, a screen full of nerve-endings which are sensitive to light. We focus our eyes to see near objects by squeezing the lens, so as to make it more nearly spherical and so make the distance of the image from the lens smaller. In old age the lens becomes hardened and the muscles can no longer compress it. We then become unable to read print when it is near our eyes and have to wear spectacles —magnifying lenses which aid the lens of the eye to converge the rays.

Microscope and Telescope

Why does a convex lens or concave mirror magnify an object held near it? Its action is to make the rays from it diverge less than they did before; that is to say, make them diverge as if they were coming from a much larger object. In Figs. 46 A and B, the rays from O are made to diverge as if they were coming from O^1, which is what the eye actually sees.

Ordinary magnifying glasses are not of much use if we want to magnify anything more than five or six times. In order to magnify a thousand times—which we need to do in order to see disease germs—we must use a compound microscope, consisting of several lenses. Fig. 47 shows how light travels through a compound microscope. The microscope gives us almost

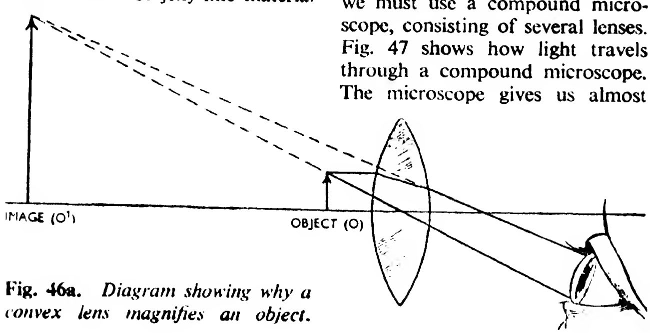


Fig. 46a. *Diagram showing why a convex lens magnifies an object.*

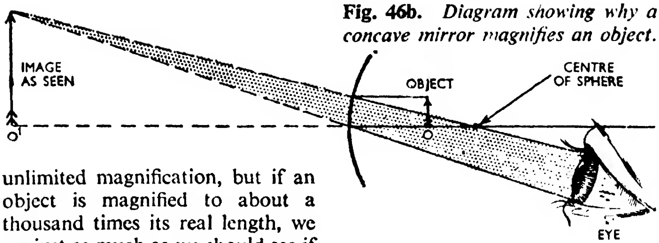


Fig. 46b. *Diagram showing why a concave mirror magnifies an object.*

unlimited magnification, but if an object is magnified to about a thousand times its real length, we see just as much as we should see if it were magnified ten thousand times. This is because light consists of waves about $\frac{1}{50,000}$ of an inch long and it is impossible for light to show us anything which is smaller than a light-wave. So no one attempts to make microscopes to magnify 4,000 or 5,000 times, for this would only give a large indistinct image; efforts are concentrated on getting the sharpest picture, not the greatest magnification.

The telescope is intended to magnify distant objects. The rays from these are necessarily very nearly parallel. The lenses of telescopes are made to bend the light, so that it diverges as if it had come from a much nearer object. A pair of opera-glasses or binoculars is, of course, simply a pair of small telescopes.

Opera-glasses are very simple and usually consist of a convex object glass and a concave eyepiece (see Fig. 48). This gives a large field of view and a very bright image. Opera-glasses usually magnify about three times and this kind of telescope is satisfactory only for these low magnifications.

The astronomical telescope in its simplest form consists of two convex lenses. This gives a picture which is upside down, which does not matter with stars, but would not do for objects on Earth. This is called a refracting telescope, but the large

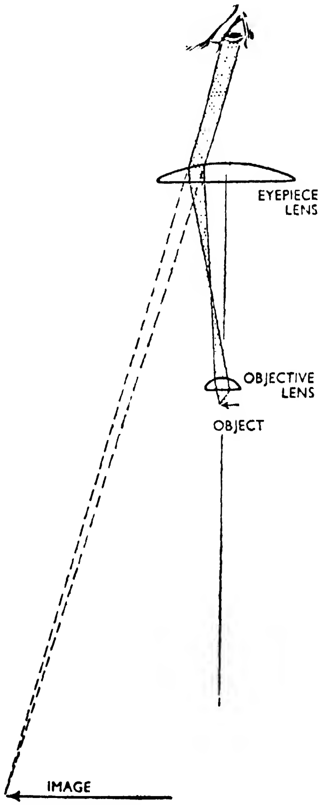


Fig. 47. *Diagram showing how a compound microscope magnifies an exceedingly minute object.*

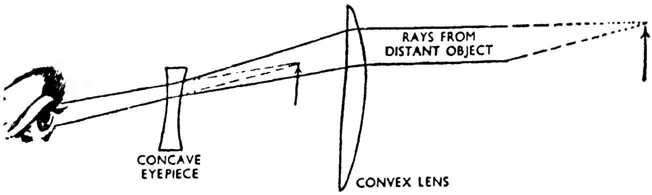


Fig. 48. *Diagram showing the principle of an opera-glass.*

lens is often replaced by a concave mirror because it is possible to make mirrors up to sixteen feet in diameter, whereas it is not possible to make perfect lenses of a diameter of more than about two feet. Refracting telescopes of the former kind are used on board ship, but two extra lenses are inserted between the other two: these have the effect of turning the image the other way up (see Fig. 49).

Such telescopes magnify the more the longer they are, so in prismatic binoculars the light is made to take a zigzag course by being totally reflected from two right-angled prisms. This also turns the image the right way up.

Colour

Colour is something we experience in our eyes and brain. To us red looks totally different from blue or yellow, but the scientist finds only small differences in the light that causes these sensations. It is simply a question of wavelength. Light which we see as red differs from light which we see as blue only as a sea with successive waves six feet apart differs from one with its waves four feet apart.

The light which comes to us from the Sun or any very hot body is not coloured but white or nearly white. This white light can, however, give rise to coloured light. When white light shines on a thin film of colourless material, such as a soap-bubble or a film of oil on a puddle, brilliant colours are seen; when one looks through a colourless prism all objects seem to be edged by a brilliantly-coloured band.

If a narrow line of light from a fine slit is focused to an image on a screen and a prism is put in the path of the beam, the line of light expands into a rainbow-coloured band or spectrum, which consists of light of red, orange, yellow, green, blue, indigo and violet, each blending into the next. These coloured lights have been made out of the white light, which is a mixture of all

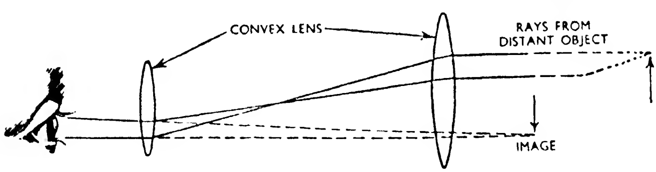


Fig. 49. *Diagram showing the principle of the astronomical telescope.*

colours. The differently coloured lights are separated by the prism, because they are refracted through different angles, the red being the least, and the violet the most bent out of its course (see Fig. 50).

If we measure the wavelengths of these different kinds of light we find that red light has the longest waves and violet light the shortest. The following table gives the figures in Ångstrom units (Å), (1 Å is $\frac{1}{10,000,000}$ of a millimetre).

Colour of light	*Wavelength*
Red . . .	6470 to 7600
Orange . .	5880 to 6470
Yellow . .	5500 to 5880
Green . . .	4920 to 5500
Blue . . .	4550 to 4920
Indigo . . .	4300 to 4550
Violet . . .	3600 to 4300

The Spectroscope

The apparatus the principle of which is shown in Fig. 50, is known as a spectroscope, and has perhaps given more valuable information than any other scientific instrument.

The angle through which it bends any particular kind of light depends on its wavelength. Now when the vapour of a chemical element, such as copper or carbon or sodium, is heated to a high temperature—as in a flame—it glows and gives out light. This is not like white light, which is of all wavelengths, but is of a few dozen particular wavelengths only.

Thus the vapour of sodium, the element in common salt, gives a bright yellow light, as may be seen by throwing a pinch of salt into a bright gas-fire. This yellow light is almost all of wavelength 5,893 Å. So when the light is passed through a spectroscope we do not see a wide band of light, but a single sharp yellow line. Now if we examine the light from a star with a spectroscope we may see this yellow line. In this way we find out that a star, so far away that its light takes a century to reach us, contains sodium. Every element gives its particular pattern of lines in exactly fixed positions, so we know what the brighter stars are made of almost as well as we know the nature of the crust of the Earth.

The rainbow is a spectrum. When sunlight enters a raindrop it is refracted and reflected. The violet rays are bent more than the red, so the observer sees only the red rays from one set of drops, the blue rays from another, the green from a third. The light is reflected at such an angle that it reaches the eye when the eye, the drop and the sun make an angle of 42 deg. This

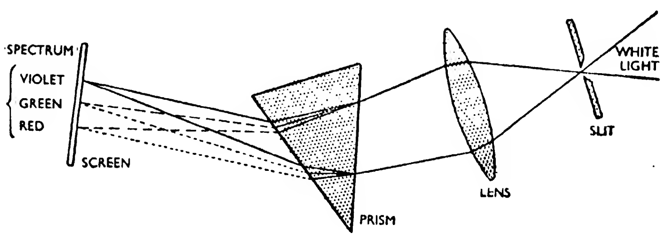


Fig. 50. *Diagram showing the principle of the spectroscope.*

can happen only when the sun is fairly low in the sky, so rainbows are chiefly seen in the evening and shortly after daybreak.

What the Eye Sees

The human eye's sensations are not a reliable guide to the kind of light that enters it. Thus we see two quite different kinds of light as of the same colour. A mixture of light of all wavelengths except that of red (white light minus red light) appears to us as green, but so also does green light of wavelength about 5,200 Å. If you stare at a red poster, then look at a white wall, you see it outlined in green. This is because you have tired out your faculty for seeing the colour red, so when you look at the wall you see white minus red, which appears green.

Thus:—

White minus	*Appears*
Red . . .	Green
Green . . .	Red
Violet-blue . .	Yellow-orange
Yellow-orange .	Violet-blue

Red and green, violet and yellow, are said to be pairs of complementary colours.

A coloured object, such as a red flower, is one which reflects only the light which we see as red. If the light which falls on it contains no red rays, the red flower obviously cannot reflect them. Thus in the light of the blue-green mercury vapour lamps, used for street lighting, red objects look brownish or, perhaps, even black.

Invisible Rays

Light is the name that we give to the radiation that the human eye can see, but no other instrument makes any distinction between light and the invisible rays that are just longer or just shorter than those that affect the eye. As we pass to longer or shorter wavelengths radiation becomes steadily more unlike light, but except to the eye there is no sharp change.

Short Waves

Just shorter than the waves of light are those of the ultra-violet radiation. The hotter a body is the greater the proportion of ultra-violet rays it emits, so the electric arc gives them in quantity. So also does the Sun, and we should be rapidly killed by sunlight if the upper layers of the atmosphere did not filter out nearly all the short-wave radiation. The small amount that comes through in clear and bright weather is of value to us. It causes the skin to become brown and forms in it the valuable vitamin D which prevents rickets—a disease of smoky towns. Too much is harmful.

Snow reflects the plentiful ultra-violet rays that reach the tops of high mountains and snow-blindness is caused by them. In tropical countries the white races may suffer from dangerous irritation of the skin caused by ultra-violet radiation. The best way of obtaining these rays is from a mercury vapour discharge lamp made of quartz, which unlike glass, is transparent to this radiation.

Ultra-violet light is invisible, but it makes many things glow or fluoresce. Thus in ultra-violet light the skin appears dark but the teeth glow. The glow often makes things visible which cannot be seen in ordinary light. There are, however, many other types of waves, such as those of X-rays and the gamma rays of radium (see Chapter 10).

CHAPTER 3

THE SOLAR SYSTEM AND THE STELLAR UNIVERSE

Ideas of the ancients. Composition of the solar system. Paths of the planets. Kepler's laws. Newton's results. Discoveries of Uranus, Neptune and Pluto. Bode's law. Asteroids and their discovery. Phases of the Moon. The Moon and the planets. Comets and shooting stars. The Sun. The stars. Double, variable and new stars. The Galactic system. Other galaxies.

To the ancients, the Earth was the centre of the Universe. They believed that it was fixed in position whilst everything else, the Moon, the Sun, the planets and the stars moved round it. The seven bodies which were known to change their positions relative to the background of the fixed stars were termed planets or wandering stars. These seven wanderers, in the order of their supposed distances from the Earth, were the Moon, Mercury, Venus, the Sun, Mars, Jupiter and Saturn. The startling theory that the Moon alone moved round the Earth, while the Earth, Mercury, Venus, Mars, Jupiter and Saturn moved round the Sun was put forward by Copernicus, the great Polish astronomer, in the sixteenth century (see Fig. 1). The book developing this theory was published in 1543, as he lay on his deathbed.

To us the Earth is merely one of a system of planetary bodies which move round the Sun. The term planet is now restricted to these bodies. Thus we regard the Earth as a planet but not the Sun or the Moon. Bodies which revolve round planets are termed satellites; the Moon is thus the satellite of the Earth. Some planets have no satellites, others have a great number.

Eight planets in addition to the Earth are now known, three planets—Uranus, Neptune and Pluto—having been discovered in comparatively modern times. There are also a few thousand small bodies, called minor planets or asteroids, whose orbits (that is paths of travel) lie between the orbits of Mars and Jupiter.

Solar System

The solar system comprises the Sun and the various bodies which are associated with it—the planets and their satellites, the asteroids and some other bodies such as comets and meteorites. The system shows a number of regular features, from which we can conclude that it has not been formed by chance. Thus, for instance, the planets all revolve round the Sun in the same direction and, with a few unimportant exceptions, the satellites all revolve round their parent planets in that same direction. The Sun and the planets rotate about their axes in the same direction as that in which the planets revolve round the Sun. The paths of the planets lie very nearly in one plane.

The plane in which the Earth revolves round the Sun is termed

the ecliptic; the orbits of the other planets, with the exception of Pluto, are inclined to the ecliptic at small angles of seven degrees or less. The paths of the satellites are also, for the most part, inclined at small angles to the ecliptic. But though these regularities could not have been brought about by the chance play of circumstance, to account for the origin of the solar system has proved to be the most baffling problem in cosmogony.

The various planets move round the Sun in accordance with certain laws, which were discovered by Kepler in the seventeenth century. Let us consider these laws,

Kepler's First Law

Kepler's first law states that the orbit of each planet is an ellipse.

The ancients regarded the circle as the perfect curve and they considered that the heavenly bodies must move in circles or in a combination of circular motions. They built up a complicated theory of epicycles (a circular motion round a centre, which in its turn has

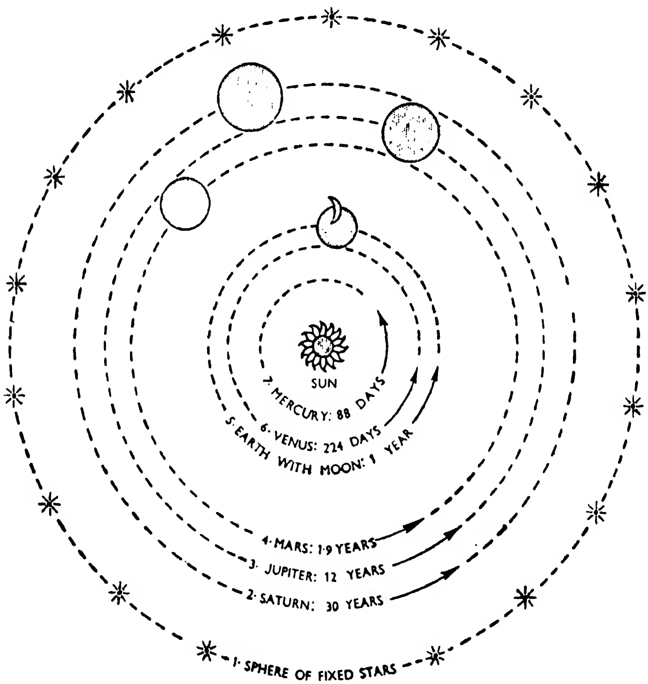


Fig. 1. *Diagram showing the Universe as depicted by Copernicus, with the known planets revolving round the Sun in circular orbits. Uranus, Neptune and Pluto had not then been discovered.*

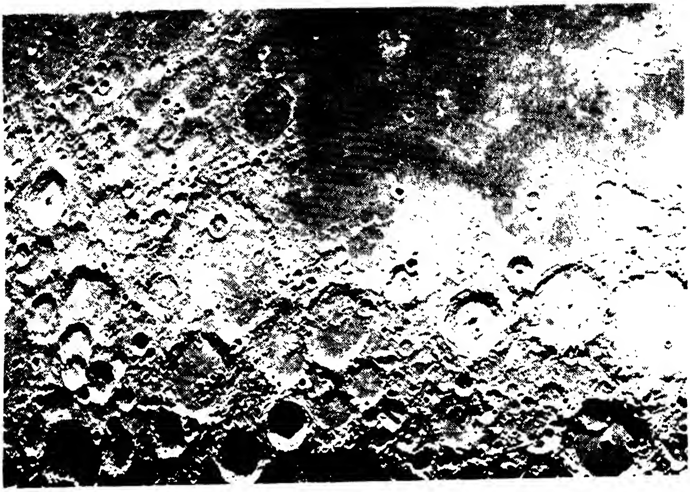


Plate I (a). *South centre portion of the Moon, near last quarter, showing ring craters of various sizes. Photographed through the 100-inch Mount Wilson telescope, many of the craters show a mountain peak in their centre.*

Plate I (b). *Group of large sunspots, photographed through the 100-inch Mount Wilson telescope. The Earth is indicated on the same scale by the black disk superimposed on the bottom left-hand corner of the photograph.*

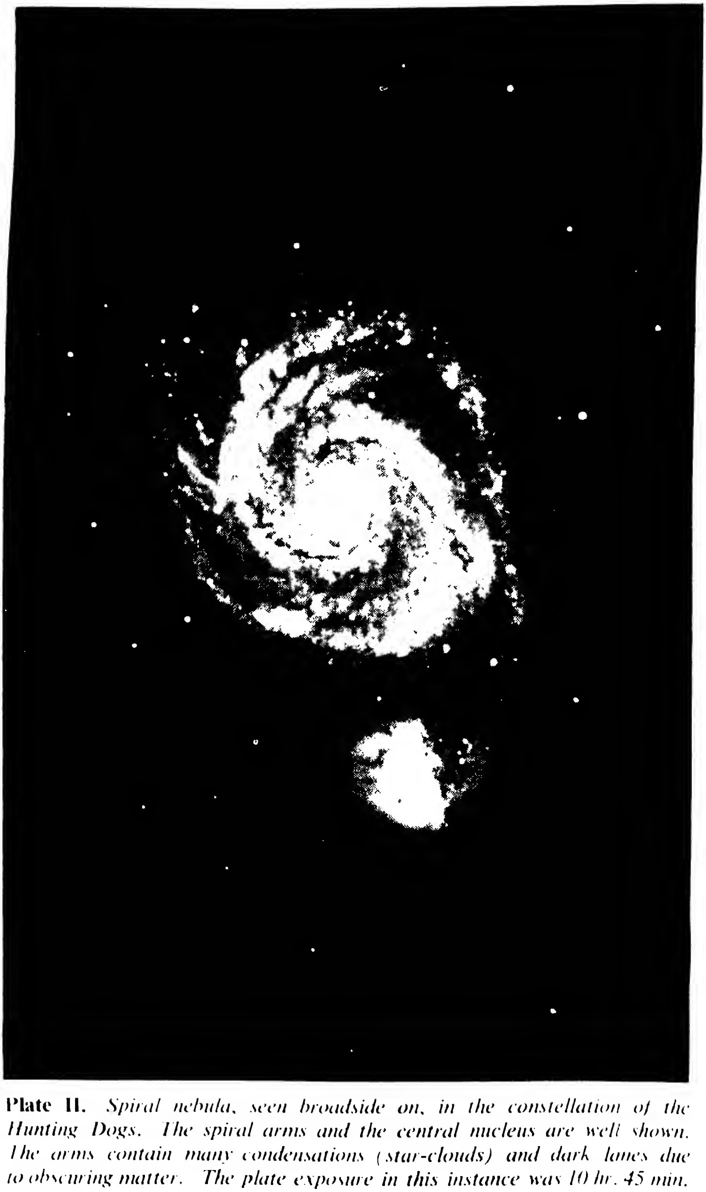


Plate II. *Spiral nebula, seen broadside on, in the constellation of the Hunting Dogs. The spiral arms and the central nucleus are well shown. The arms contain many condensations (star-clouds) and dark lanes due to obscuring matter. The plate exposure in this instance was 10 hr. 45 min.*

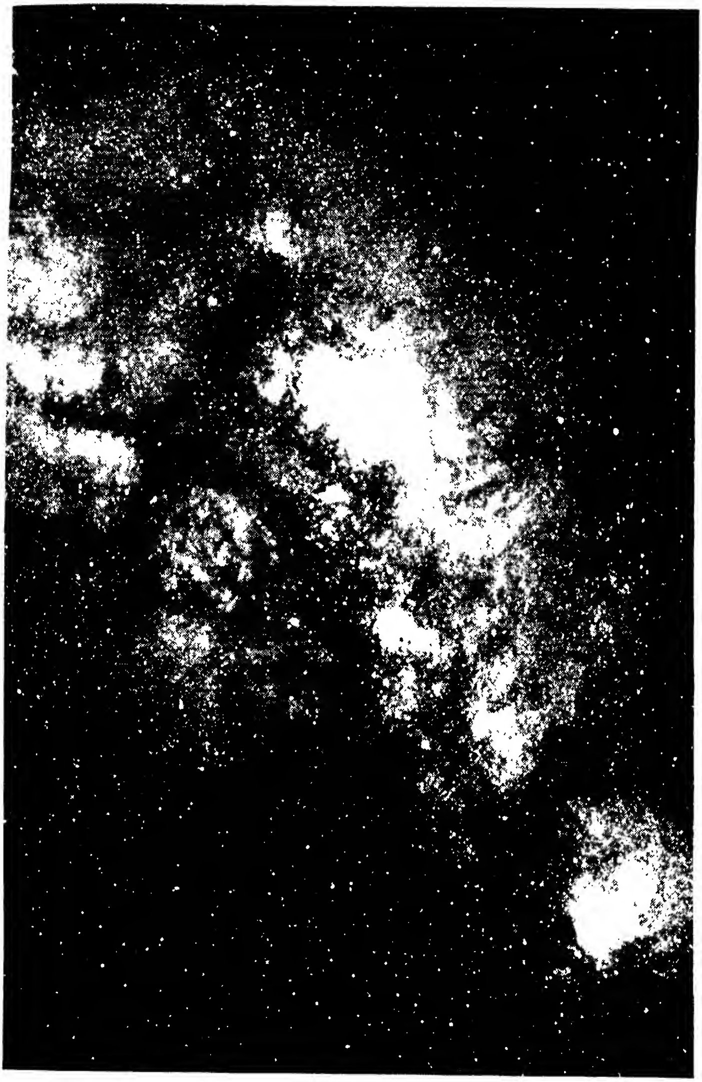


Plate III. *Portion of the Milky Way in the constellation of Sagittarius in the southern sky. This is the brightest part of the Milky Way, and the star images are so densely aggregated that they merge together. Note the dark lanes, containing few stars, which are caused by obscuring matter.*

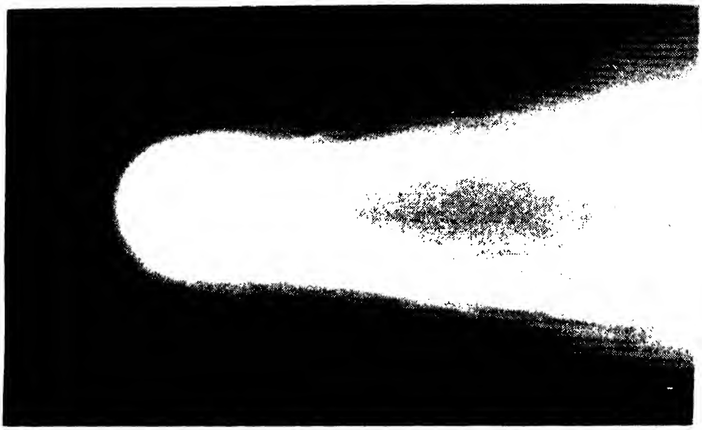


Plate IV (a). *The head and part of the tail of Halley's Comet, May 8, 1910. Note that in the tail (on the right of the picture) the short white streaks are trailed images of stars, some of which are clearly visible through the tail.*

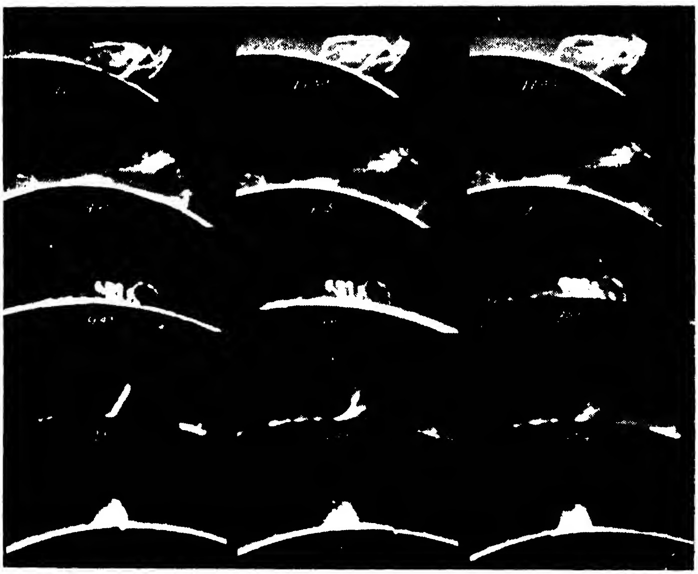


Plate IV (b). *Five examples of flames of gas (each some thousands of miles high) at the edge of the Sun. Three views of each, separated by a few minutes in time, are shown. Note the considerable changes in structure.*

another circular motion) to account for the observed movements of the planets. Copernicus, though he showed that a considerable simplification was obtained by supposing that the planets moved round the Sun instead of round the Earth, was still tied to the idea of circular motions. Kepler was the first to break away from this idea. After long continued investigations, he proved that the path of each planet is an ellipse (see Fig. 2).

If A and B are two fixed points and the point P moves so that the sum of the distances PA and PB remain unchanged, P describes an ellipse; the two points A and B are called its foci. An ellipse can be drawn by passing a loop of cotton round two pins A and B, fixed in a board; and running a pencil round in the loop of the cotton. For a given length of string, the nearer A and B are brought together the more closely does the ellipse approach a circle; when A and B coincide, the path of P is circular. Kepler's first law defines the shape of the orbit of each planet: it is an ellipse and the Sun is at one of the foci.

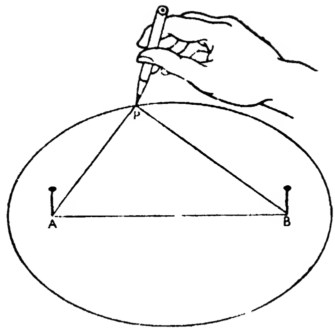


Fig. 2. *Diagram showing a convenient way of drawing an ellipse*

Kepler's Second and Third Laws

Kepler's second law states that each planet revolves so that the line joining it to the Sun sweeps over equal areas in equal intervals of time (see Fig. 3). This law describes the way in which each planet moves in its orbit. The motion of a planet round the Sun is not constant. It is most rapid when the planet is nearest to the Sun and is slowest when it is farthest away. Thus, if the areas SAB, SCD are equal, the planet takes the same time to move from C to D as from A to B.

Kepler's third law gives a simple relationship between the times which different planets take to make a complete turn round the Sun and the sizes of their orbits, and so enables the distance of any planet from the Sun (in terms of the distance of the Earth from the Sun) to be inferred when the time which the planet takes to revolve round the Sun has been found.

If, for instance, a planet takes eight years to complete one revolution, it must be (in accordance with this law) four times more distant than the Earth from the Sun. By merely observing the periodic times of the planets, it therefore becomes possible to draw the solar system to scale. The fixing of any one distance in this scale picture then settles the size of the whole solar system. The distance of the Earth from the Sun can therefore be found if the distance of any member of the solar system can be determined. This is a result of the greatest importance. It is possible, for instance, by making observations of the position of Mars in the sky to find how far away the Sun is; it is not necessary to make any observations of the Sun itself.

Kepler spent many years in

laborious calculations in his attempts to find laws which would fit the observed motions of the planets before he eventually arrived at the simple laws which bear his name. It was the great achievement of Sir Isaac Newton (1642-1727) to link these laws together and to show that they followed logically from the law of gravitation.

Law of Gravitation

Newton's results were published in 1687 in his immortal work, the *Principia*, perhaps the greatest of all scientific treatises. In effect, Newton's law of gravitation states that every piece of matter exerts a pull on every other piece of matter; the pull is greater the nearer the two pieces of matter are to one another.

It is the force of gravitation that causes a body to fall to the ground with a definite acceleration, that holds the Moon in its orbit round the Earth, and that holds the Earth and the other planets in their orbits round the Sun. Just as, when a stone is whirled round on the end of a string, it is the pull of the string that prevents the stone from flying away, so it is the invisible pull of the Sun (its gravitational attraction) that prevents the Earth and other planets from flying away. Newton showed that the motions of the planets under the controlling influence of the Sun's gravitational attraction must obey Kepler's three laws.

We have mentioned that the orbit of each planet is an ellipse. This is not strictly true because, in consequence of the universality of gravitation, each planet attracts every other planet: these mutual attractions vary as the distances of the planets from one another vary and cause the planets to deviate slightly from their elliptical paths.

The disturbances in the path of a planet caused by the varying attractions of the other planets can be calculated, and the precise position of the planet at any time in the future can be predicted. If the gravitational forces have been correctly allowed for, the observed position of the planet should be in close agreement with the calculated position. The planet Uranus provides an interesting illustration. Uranus was discovered by William Herschel in 1781, with a telescope of his own making. He noticed that its image showed a small disk and was different from the pin-point image of a star. He thought at first that it was a comet, but it was soon proved to be a new planet—the first planet to be discovered by Man.

Several astronomers before Herschel, including Flamsteed, the first Astronomer Royal, had actually observed Uranus, but with their small telescopes its disk could not be perceived and it had been recorded as a star. These earlier observations were of use in determining the orbit of the new planet. But it was found that Uranus was departing from its scheduled place.

Neptune and Pluto

Two astronomers, Adams in England and Leverrier in France, independently assumed that Uranus was being disturbed by an unknown planet and set to work to determine the position of this planet. The positions they derived were in close agreement. Challis in Cambridge and Galle in Berlin undertook a search for the new planet. Galle was fortunate in having some star-maps of the region in which the planet was to be looked for and on September 23, 1846, detected an

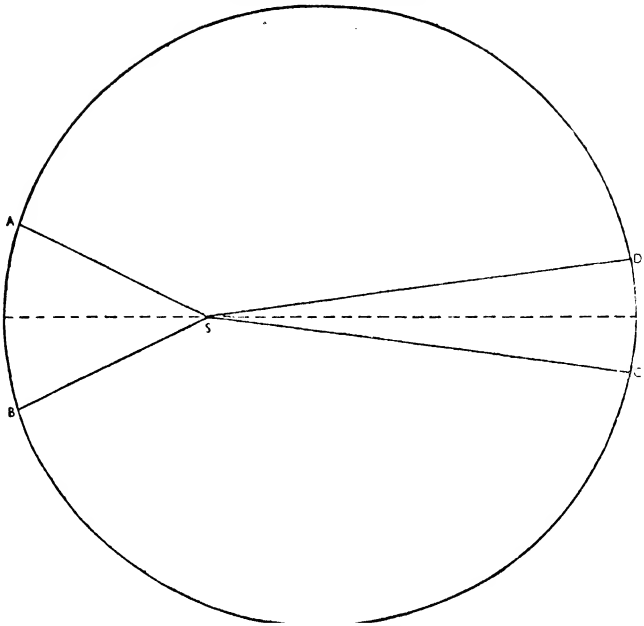


Fig. 3. *Diagram illustrating Kepler's second law, which describes how a planet moves in its orbit. If the areas of the triangles SAB and SCD are equal, a planet will take the same time to travel from C to D as from A to B.*

object which was not shown on his maps and which proved to be the new planet. Challis had already observed it on two nights but, having no star-maps, he was forestalled in the discovery by Galle. The new planet was called Neptune.

As observations of Uranus and Neptune were collected, it was found that there were slight discrepancies in the motions of both planets. Lowell investigated these and, assuming again that they were caused by an unknown planet, derived an orbit for this body. After a search lasting for several years, a faint distant planet was detected on long-exposure photographs taken at the Lowell Observatory in Arizona. This planet was given the name of Pluto; the name of the god of the nether regions was peculiarly appropriate, for its first two letters are the initials of Percival Lowell, the founder of the observatory at which the planet was discovered, and whose calculations had stimulated the search for it.

It follows from Kepler's third law that the more distant a planet is from the Sun the longer is the time that it takes to describe its orbit. It can also readily be shown that the more distant the planet, the slower is its speed in its orbit.

Thus, for example, Mercury takes eighty-eight days to complete a revolution round the Sun, its mean

distance being 36 million miles and *its speed about thirty miles a second*; Pluto takes nearly 250 years to complete a revolution, its mean distance being 3,670 million miles and its speed nearly three miles a second. The speed of the Earth is approximately 18½ miles a second.

Bode's Law

Before the discovery of Neptune, it was noted that the distances of the planets could be found by using a certain rule, known as Bode's law. Write down the series of numbers 0, 3, 6, 12, 24 . . . in which each number (after the first) is double the preceding. Now add 4 to every number. Bode's law states that the numbers so obtained represent fairly closely the relative distances of the planets from the Sun, the distance of the Earth being taken as 10 (see table below).

It will be seen that the law holds fairly well for the planets up to Uranus, but that it fails for Neptune and Pluto, the actual distance of Pluto being approximately equal to the distance required by Bode's law for Neptune. No planet was known corresponding to the distance 28, between Mars and Jupiter. But on January 1, 1801, Piazzi at Palermo discovered a small body at about this distance, to which the name Ceres, after the tutelary deity of the island, was given.

Shortly afterwards two other small bodies at about the same distance were discovered: Juno in 1804 and Vesta in 1807. There were no further discoveries until 1847, but since then many new tiny planets or asteroids have been discovered, so that some 2,000 of these small bodies are now known. The origin of the asteroids is not known but it is thought possible that they may have been produced by the disruption of a planet which was situated between Mars and Jupiter.

The asteroid Eros is of special interest, as it occasionally comes sufficiently near the Earth to enable its distance to be accurately determined, whilst it is sufficiently bright to be easily observed. Its nearest approach to the Earth since its discovery in 1897 occurred in 1931, when it approached to a distance of about 16 million miles. From extensive observations of Eros at that near approach the scale of the solar system was obtained; the mean distance of the Earth from the Sun was found to be 93,005,000 miles, which is the most accurate estimate that has yet been made.

Phases of the Moon

The planets and their satellites are not self-luminous bodies; we see them only by means of light from the Sun which falls upon them and is reflected by them. It is to this cause that the phases of the Moon are due. At any time, half of the Moon's

Bode's Law of Planetary Distances

	Mercury	*Venus*	*Earth*	*Mars*	*(Asteroids)*	*Jupiter*	*Saturn*	*Uranus*	*Neptune*	*Pluto*
By Bode's law .	4	7	10	16	28	52	100	196	388	772
Actual distances .	3·9	7·2	10	15·2	—	52	95	192	301	396

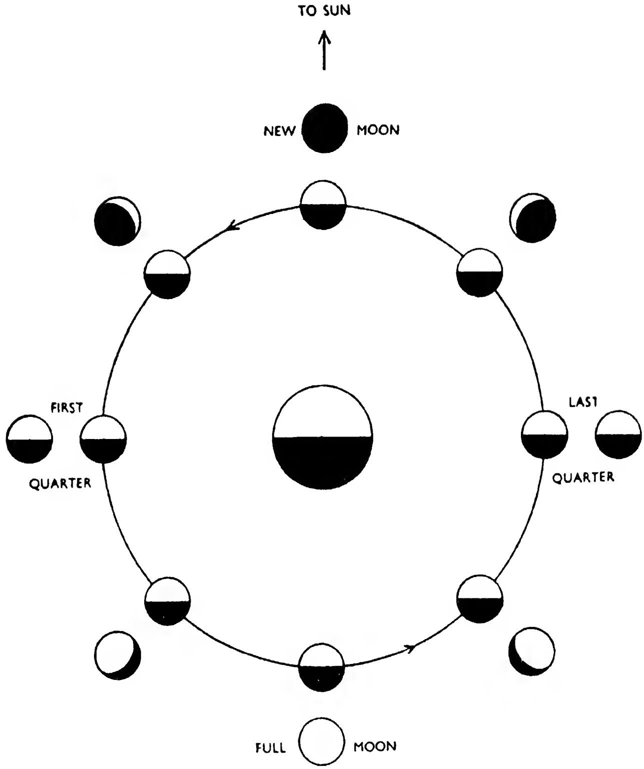


Fig. 4. *The Moon at different positions in its orbit, with half its surface illuminated by the Sun, and (outer circle) the appearance of the Moon as viewed from the Earth, shown in the centre of the diagram.*

surface is illuminated by the Sun; the other half is in darkness. The proportion of the sunlit face that we can see depends upon the position of the Earth in relation to the direction from the Sun to the Moon. When the Earth is between the Sun and the Moon we see the whole of the sunlit face of the Moon; it is then Full Moon. When the Moon is between the Sun and the Earth, we face the dark side of the Moon; it is then New Moon. When the direction from the Earth to the Moon is at right angles to the direction from the Moon to the Sun, we see half the sunlit face: it is then first or last quarter.

The phases of the Moon are illustrated in Fig. 4. The inner planets, Mercury and Venus, show a complete succession of phases like the Moon but a telescope is needed to reveal them; the phases of Venus were amongst the first discoveries made in 1610 by Galileo with his

primitive telescope. The outer planets, which are more distant than the Earth from the Sun, show only a slight phase effect; in the case of Mars, the nearest of these planets to the Earth, about one-eighth of its disk can be obscured.

Eclipses

If the orbit of the Moon round the Earth were in the same plane as the orbit of the Earth round the Sun (the ecliptic) the Moon would come directly between the Earth and the Sun at every New Moon and there would be an eclipse of the Sun; the Earth would come directly between the Sun and the Moon at every Full Moon and there would be an eclipse of the Moon. There would then be an eclipse of the Sun and an eclipse of the Moon every month. But the orbit of the Moon is inclined at an angle of about 5 deg. to the ecliptic; eclipses of the Sun or Moon can therefore only occur when the Moon is near one of the points where its path crosses the ecliptic. It can be shown that there must be at least two eclipses in a year; when there are only two, they must both be eclipses of the Sun. There may be as many as seven eclipses in a year, which will be either five solar and two lunar, or four solar and three lunar.

The Moon and the Planets

The planets and their satellites differ considerably in size, but all are much smaller than the Sun (see Fig. 5). Taking the Earth with a diameter of 7,900 miles, as the standard of comparison, the Moon is a relatively small body, with a diameter of only 2,160 miles. Two of the planets, Mercury and Mars, are appreciably smaller than the Earth, with diameters of 3,000 and 4,200 miles respectively. Venus is but slightly smaller than the Earth. Jupiter, Saturn, Uranus and Neptune, which are known as the major planets, are all much larger than the Earth; Jupiter, the largest and most massive of the planets, could contain 1,300 bodies of the size of the Earth. The average densities of these four planets are much less than those of the smaller planets; the average density of Saturn is actually less than that of water. The major planets have very deep atmospheres; in determining their average densities, the rocky cores and the atmospheres are lumped together.

The satellites have a wide range in size: the largest are comparable with the Moon or Mercury, whilst the smallest are only a few miles in diameter. Mercury and Venus have no satellites; Mars has two tiny ones; Jupiter has four large and seven small satellites; Saturn has one large satellite and eight others of intermediate size; Uranus has four satellites of moderate size while Neptune has only one, which is about the size of Mercury. Little is known about Pluto; it is probably comparable in size with the Earth and no satellite to it has been detected.

The Sun has a diameter of 864,000 miles. It could therefore contain about 1,000 bodies the size of Jupiter or 1,300,000 bodies the size of the Earth. The relative sizes of the Sun and planets are indicated in Fig. 5.

The temperature of a planet can be calculated from its distance from the Sun. Consider, for instance, the Earth. We know that its interior is warm; evidence for this is provided in various ways, such as the increase in temperature in going down a mine

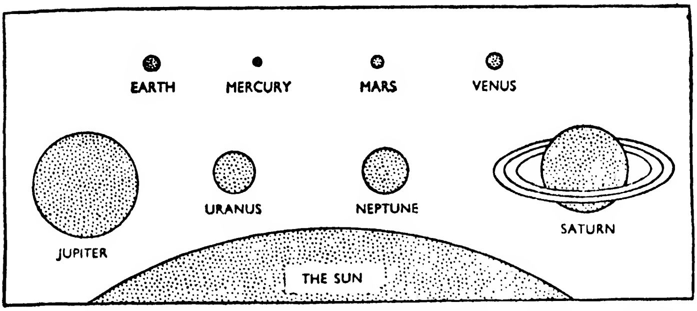


Fig. 5. *Relative sizes of the Sun and the planets. The outermost planet, Pluto is not shown here as little is at present known about its size or composition.*

or by the existence of volcanoes, geysers and hot springs. If the Earth received no heat from the Sun, heat would gradually flow outwards from its interior and the Earth would get cooler and cooler. But it is continually receiving heat from the Sun and a state of equilibrium has been attained, in which the heat received from the Sun just balances the heat flowing out. This makes it possible to calculate the temperature of each planet; the calculated temperatures agree closely with the temperatures found by direct measurement at the telescope. The greater the distance of a planet from the Sun the cooler the planet must be.

The major planets and Pluto are inconceivably cold, judged by the Earth's standard of comparison. The average temperature of Jupiter is —140 deg. C., which corresponds to 250 deg. of frost on the Fahrenheit scale; the others are considerably colder than this. Mercury, on the other hand, with a temperature of 400 deg. C. is about as hot as molten lead. Venus is distinctly warmer than the Earth, whilst Mars is appreciably cooler.

The Moon is our nearest celestial neighbour, only 240,000 miles away, and we can study its surface in considerable detail. If an astronomer of the Moon were to look at our Earth with a powerful telescope he would see continents, islands, oceans, lakes, rivers and great mountain ranges; he would notice that large areas were often obscured from view by clouds, but that these clouds had no permanence of form or extent; he would see the polar caps of ice and snow; he would detect changes of colouration, caused by the seasonal growth and dying away of vegetation.

Features of the Moon

With long continued observation he would notice that other changes were taking place: the growth of large cities and the impounding of rivers or valleys to form artificial reservoirs would be apparent. These he might interpret as the work of intelligent beings. But when we look at the Moon we see none of these things: we see an arid rugged mountainous world, without oceans, lakes or rivers; there is no trace of vegetation and no clouds ever obscure the surface. It is a world without change, a world without

life, a dead world. It is a world, moreover, that is completely devoid of atmosphere. This is best proved, perhaps, when the Moon, near its first quarter, passes in front of a star, in its eastward motion across the sky. As the dark invisible edge of the Moon passes in front of the star, the star disappears instantaneously. If the Moon possessed an atmosphere, the star would gradually fade from sight. Being without an atmosphere, life on the Moon is necessarily impossible.

A striking feature of the Moon is the great number of ring mountains (see Plate IA) of all sizes from small ones, less than a quarter of a mile in diameter, to very large ones, 100 or 150 miles across. These ring mountains or craters may be of volcanic origin or they may have been produced by the impact of many great meteors, when the Moon's surface was still plastic. The Earth has no corresponding formations—they may have existed in the early days of its history and have disappeared in the successive stages of mountain uplift and erosion by wind and water.

Loss of Atmosphere

It is of some interest to inquire why the Moon has no atmosphere. The natural tendency of a gaseous atmosphere on any planet is to leak away into space; but this tendency is held more or less in check by the gravitational pull of the planet. If the gravitational pull of the Earth could be overcome, its atmosphere would leak away into space almost instantaneously. In general, there will be a definite rate of loss for each of the gases of the atmosphere of a planet, depending upon the gravitational pull and the temperature of the planet. The lighter the gas the more rapid the rate at which it can escape from a given planet; the higher the temperature, the more rapid the rate at which every gas in the atmosphere will escape. The rate of escape can be calculated.

Atmospheres of Planets

It is found that the atmosphere of the Earth, at the present time, could not lose even the lightest gas—hydrogen. But as it contains very little hydrogen or helium, the two lightest and most common elements in stellar space, it can be inferred that the Earth has cooled to its present condition from a very much hotter state and that it remained hot sufficiently long for most of the hydrogen and helium in its earliest atmosphere to escape, but not long enough for the heavier gases to escape.

Considering the other planets, the four major planets have such a strong gravitational pull that, even when they were hot, they were able to retain the whole of their early atmospheres: they therefore have very extensive atmospheres, which are rich in hydrogen and helium. Mercury, at the other extreme, has lost all its atmosphere. Venus has an atmosphere comparable in extent to that of the Earth, whilst Mars has a much thinner atmosphere.

The atmospheres of the Earth and of its twin sister, Venus, are markedly different in their composition. Whereas the atmosphere of the Earth is rich in oxygen and contains little carbon dioxide, that of Venus is rich in carbon dioxide and contains little, if any, oxygen. Venus is an extremely arid world, subject to perpetual and violent dust storms, which make her atmosphere so cloudy and thick that her surface can never be seen. The

absence of oxygen and water on Venus suggests that there can be little or no vegetation there; it is the extensive vegetation on the Earth which is responsible for the considerable amount of oxygen in the atmosphere of our planet.

Mars and Major Planets

Mars is in many ways the most interesting of the planets. We can see her surface, with dusky markings on a ruddy background. White polar caps appear and disappear around her poles, with the alternation of the seasons, but they are neither so extensive nor so thick as the Earth's polar caps; the rapid rate at which they melt in summer proves that they are not more than a few inches in thickness.

Clouds are often seen on Mars and have a tendency to form soon after noon. The maximum temperature on Mars is about 50 deg. F., but the changes of temperature, in consequence of the thin atmosphere, are rapid and considerable. The minimum temperature at night is about —130 deg. F.

The dusky areas of the planet show changes in colouration with the seasons, and some changes in configuration from one Martian year to another. It seems pretty certain that these changes are due to vegetation of some sort. The nature of the finer details of the surface markings, to which the name of canals has unfortunately been attached, has given rise to much controversy. Lowell considered that they were artificial waterways, made by intelligent beings engaged in a struggle for existence on a world becoming progressively more arid. But this view is not generally accepted today. We can find no evidence of animal life on Mars, though we cannot say that the conditions on the planet are such that life of some sort is impossible.

The major planets are generally similar in their conditions. They are cold worlds, surrounded by ice coatings several thousands of miles in thickness. Over these are atmospheric layers of very great extent, consisting mainly of hydrogen and helium. The pressure of the atmosphere of Jupiter at its surface is about a million times the pressure of the Earth's atmosphere, and is so great that the hydrogen and helium are liquefied.

Methane or marsh gas is an important constituent of the atmospheres of all four planets. Ammonia is also prominent in Jupiter's atmosphere, but less so in that of the colder planet Saturn; Uranus and Neptune are so cold that ammonia cannot exist as gas, but is liquefied out of the atmospheres.

The several planets of the solar system therefore show a great diversity in their general conditions. With the exception of the Earth and Mars, it seems certain that life cannot exist on any of them; on Mars, there is evidence of vegetation but conditions are not very promising for any form of animal life. The extensive vegetation on the Earth, providing an abundant supply of oxygen, together with a moderate temperature and an ample supply of water and moisture have combined to give conditions favourable for the development of a great variety of animal life.

Halley's Comet

A bright comet, with a flaming tail stretching across the sky, is a striking object in the heavens. Before the nature of comets was understood, it was thought that the

appearance of a bright comet was a herald of some important event and often a harbinger of misfortune. A bright comet (Halley's) appeared in A.D. 1066 at the time of the Norman invasion, and is depicted on the famous Bayeux tapestry as an omen of success for William of Normandy and of disaster for King Harold.

Halley, the second Astronomer Royal, collected the observations of twenty-four bright comets and calculated their orbits. He noticed that the orbits of the bright comets that had appeared in the years 1531, 1607 and 1682 were almost identical and concluded that these comets must be one and the same. He predicted that the comet would return near the end of the year 1758. Halley died in the year 1742.

As the time for the return drew near, there was great excitement amongst the philosophers of the age, for comets had always been regarded as chance visitors. The comet returned as predicted, being first seen on Christmas Eve, 1758. It was thus proved that comets, like the planets, move under the control of the Sun's gravitational attraction. A remarkable test of Newton's law of universal gravitation was thus provided and at the same time it was established that a comet moves in obedience to definite laws. It was obvious therefore that the appearance of a comet could bear no relation to earthly happenings.

Comets and Shooting Stars

The orbits of comets are for the most part extremely elongated; most comets, when farthest from the Sun, are far beyond the most distant planet. The comet is then invisible, it moves slowly and is subject to intense cold. As it nears the Sun, on its approach, it moves more and more rapidly and its temperature rises.

The bright head of a comet is not a solid body like the Earth, but is a loose collection of rocks, stones and particles of dust; the pressure of the Sun's radiation drives the small dust out from the head, producing the luminous tail (see Plate IVA) which points away from the Sun. It is the tail that makes a bright comet such a striking object and gives rise to the name comet, meaning "hairy star." The tail is extremely tenuous: a star, seen through it, appears quite undimmed. The Earth has on occasion passed through the tail of a comet, without any detectable effect. As the tail contains poisonous carbon monoxide and cyanogen gas, it is fortunate that its density is so low: 10,000 cubic miles of tail do not contain more matter than one cubic inch of ordinary air.

But spectacular though a bright comet is, with its tail stretching away for millions of miles, the weight of a comet is insignificant compared with the weight of the planets. The largest comet weighs less than one-millionth part of the Earth's weight. Comets represent, in fact, merely the debris of the material that did not condense to form planets or satellites.

Occasionally a comet is lost to the solar system through the disturbing action of a planet, usually Jupiter. When a comet passes near Jupiter, its orbit may be changed from an elongated ellipse to a parabola or hyperbola — curves which are not closed. It then travels on, never to return. But there is no evidence of a comet ever having entered the solar system from outside. The great majority of comets are periodic, that is, they return at regular intervals (except

for variations caused by planetary perturbations). The comet with the shortest period is Encke's comet, which returns every 3½ years and which has been observed at every return since 1786. Halley's comet has a period of about seventy-six years. But most comets have periods of many hundreds or thousands of years; the returns of these comets have not yet been seen.

The appearance of a shooting star or meteor is caused by a small particle of matter, usually smaller than a pea, which, entering the Earth's atmosphere at a speed many times greater than that of a rifle bullet, is heated to incandescence by friction and rapidly becomes a gas. The Earth in its journey round the Sun encounters several millions of these fragments in the course of a day. If the fragment is sufficiently large, it appears as a meteorite or fireball, leaving a long flaming streak behind it; it will not be completely vaporized in its passage through the Earth's atmosphere and it will fall to the Earth. The Great Meteor Crater in Arizona, more than a mile across and about 600 feet deep, was made by the impact of a meteoric mass estimated to have weighed one million tons. Most meteors, like comets, belong to the solar system, and travel with the Sun in its journey through space. But there are others which unlike comets, are swept up from outside the solar system.

There is a close connexion between comets and meteors. Occasionally a brilliant meteor shower is observed, caused by a stream of meteoric particles, travelling in a definite orbit, entering the Earth's atmosphere. Comets have been observed to disintegrate into two or more parts, and become spread out along their orbit as a trail of stones and dust. When a comet which has become disintegrated is due to return, the comet is no longer seen, but there is instead a brilliant shower of meteors as the Earth crosses the comet's track. The brilliant meteor shower of November 13 and 14, 1866, when many thousands of shooting stars flashed across the sky, was caused by the debris of Temple's comet.

The Sun

The Sun, being a self-luminous body, is a star—the nearest star to the Earth. It is of special importance to us, as the giver of light and heat, which make life on the Earth possible. It is both much larger and much more massive than the Earth, having 1,300,000 times the volume of the Earth and 300,000 times its mass. The temperature of the Sun's surface is about 6,000 deg. C.; what such a temperature means can be better realized by stating that every square inch of its surface is continually sending out energy at the rate of a sixty horse-power engine.

The Earth only receives one part in 2,200 millions of the energy radiated by the Sun; yet, at the rate of 1d. per Board of Trade unit, the value of the energy from the Sun falling on the Earth each second amounts to more than £200,000,000. If but a small fraction of this energy could be harnessed, there would be no need to worry about the future exhaustion of the coal and oil reserves which at present provide our main supplies of power.

The age of the Earth has been estimated from the study of radioactive rocks, which contain helium and lead as products of the disintegration of the radioactive elements; it is found to be not less than

3,000 million years. The Sun must be at least as old.

How has the Sun been able to maintain its high output of radiation for so long a time? Lord Kelvin suggested that the Sun was slowly contracting under its own gravitation; such contraction would make it tend to grow hotter and would provide it with the energy needed to maintain its radiation, just as compressing air in a bicycle pump warms it. But the energy that can be obtained in this way would not maintain the Sun's radiation for more than about 25 million years, and is hopelessly inadequate.

It is now known that the Sun is able to draw on some of the energy locked up in the interior of the atom. This is made possible by the extremely high temperature in the Sun's interior; the temperature at the Sun's centre is about 20,000,000 deg. C.

Geological evidence has indicated that there have been alternations of warm periods and ice ages in the past history of the Earth. Thus the Sun's output of energy has not been absolutely regular in the past. The variations have fortunately been small in amount: if they had been comparable with the variations shown by many other stars, life would have ceased to exist on the Earth many ages ago.

Composition of Sun

The material composition of the Sun can be discovered by studying its light. It is known that every element or simple substance, when heated until it becomes vaporized, produces its own special kind of light; thus by means of a spectroscope, which is an instrument for separating a mixture of lights into their simplest parts, it is possible to analyse the light from the Sun and so identify the elements present, just as surely as a person can be identified by his thumb-prints.

The Sun is found to consist, by and large, of the same elements as the Earth. No element is found in the Sun that has not been found on the Earth. One element was, indeed, discovered in 1868 in the Sun which was at that time unknown on the Earth; this unknown element was accordingly called helium (from the Greek word for the Sun). In 1895 it was proved to be present in very small quantities in the air we breathe; it is, next to hydrogen, the lightest substance known. A few elements which occur on the Earth have not been detected in the Sun; but there are special reasons which account for the failure to detect them, such as great rarity or the lack of suitable means.

Sunspots

One of the first things Galileo discovered when he turned his primitive telescope on the Sun in 1610 was that dark spots were usually to be seen on it, and that these spots appeared to drift across the Sun's surface. He correctly accounted for this apparent drift as an effect of the rotation of the Sun around an axis in about twenty-seven days.

Later it was found that the number of spots that appeared on the Sun varied in a systematic way, rising to a maximum number and then falling to a minimum number and then rising again; the complete cycle takes about eleven years. A sunspot minimum occurred in 1944, and the number of spots will go on increasing until about 1949.

Large spots, which may be more than 100,000 miles in diameter, are

readily visible to the naked eye when the Sun is viewed through a darkened glass. A sunspot is like a gigantic hollow whirlpool, from which matter streams outwards and upwards (see Plate IB). The matter cools as it expands; though the spot appears dark by contrast with the brighter background of the surface, it is in reality intensely bright and hot, its temperature being about 4,500 deg. The direction of circulation within the sunspot eddy or whirlpool is opposite in the two hemispheres, as is the case with cyclonic disturbances on the Earth. Very intense magnetic forces, comparable in strength to that between the pole pieces of a fair-sized dynamo, occur in sunspots.

It has been claimed that sunspots have an effect on the weather. But the factors that combine to produce the weather are extremely complex, and no marked connexion between sunspots and weather has ever been established, though the annual rings of certain trees, such as the giant redwood trees of California, show variations in their spacing which correlate with sunspots. There is a very close relationship, on the other hand, between the solar cycle and variations in the Earth's magnetism. Magnetic storms, when telegraph and telephone circuits are apt to be interfered with and the compass needle is set in violent vibration, are most frequent when sunspots are most numerous. Sudden radio fadings and displays of the aurora also occur most often at these times.

Solar Flames

Great flames of incandescent gas may often be seen extending out from the Sun's edge (see Plate IVB). They may persist for a considerable while, but at times they are seen to dissipate with great violence, the gaseous matter being shot away from the Sun with a speed of about 1,000 miles a second. In about twenty-four hours this matter can travel the distance between the Sun and the Earth; if it comes near the Earth, the particles of matter, which are electrically charged, are influenced by the Earth's magnetism and move spirally inwards towards the magnetic poles. Electric effects are then produced, which give rise to displays of auroræ. The upper layers of the atmosphere become electrically charged and large electrical currents circulate in them, which produce magnetic effects. At the same time ordinary radio waves are upset. So we get magnetic storms, radio fadings and auroral displays—all caused by phenomena occurring on the Sun.

The Stars

Saint Paul said that "one star differeth from another star in glory." When we look at the heavens we see bright stars and faint stars. But one star may appear brighter than another either because it is intrinsically brighter or because it is nearer. So it is necessary to find the distances of the stars before we can obtain any information about their actual brightness. The stars are suns—self-luminous bodies—and because they appear so much fainter than our Sun they must be much more distant. We should, in fact, have to view the Sun from a distance of about 30 million million miles for it to appear as a star of the first magnitude.

Because stellar distances are so great it is convenient to express them in terms of light-time. Light travels at 186,000 miles a second and takes about eight minutes to reach

the Earth from the Sun. So we see the Sun as it was eight minutes previously. Light takes 5½ hours to travel from the Sun to the most distant planet Pluto. Travelling on beyond the confines of the solar system, it would take about four years, corresponding to a distance of about 25 million million miles, to reach the nearest known star. If we represent the Sun, whose diameter is 864,000 miles, by a tennis ball and imagine half a dozen tennis balls to be moving inside a hollow sphere the size of the Earth—8,000 miles in diameter—we have a fairly true idea of the comparative emptiness of space.

Very refined and accurate measurements are needed to find star distances. But the distances of several thousand stars are now known and it thus becomes possible to compare the actual brightness or candle-powers of these stars. We find that the stars differ very greatly in their candle-power; the bright star, Canopus, for instance, has a luminosity about 80,000 times that of the Sun; Proxima Centauri, the nearest known star, on the other hand, has a luminosity only one ten-thousandth of that of the Sun.

Now these differences in luminosities may be due to two factors: to differences in size or to differences in actual brightness per unit area of surface. Let us consider the second factor first; when we look at the stars, we see that they differ in colour—some are blue, some are white, some are yellow and some are red. These differences of colour correspond to differences in temperature, just as molten steel in cooling passes successively through the stages from a white heat to a dull red heat.

The temperatures of the stars range from about 30,000 deg. C. for the blue stars to about 2,500 deg. for the red stars. The intrinsic brightness per unit area of the surface of a star depends only on its temperature, being greater the higher the temperature. So we are able to allow for the differences in temperature when comparing the candle-powers of different stars and thus to obtain the surface areas and the sizes of the stars. The differences in size prove to be far greater than the differences in temperature. The bright star Antares, for instance, has a diameter 480 times that of the Sun; if the Sun were placed at the centre of Antares the orbit of Mars would fall well within the star. The star known as Procyon B, on the other hand, proves to be smaller than the planet Neptune (see Figs. 6 and 7).

Mass and Density of Stars

It may seem surprising that a star can be smaller than a planet. But there are essential differences. A star is self-luminous but a planet is not, and the mass of a star is greater than that of a planet. The stars do not show as wide a range in mass as they do in luminosity or size.

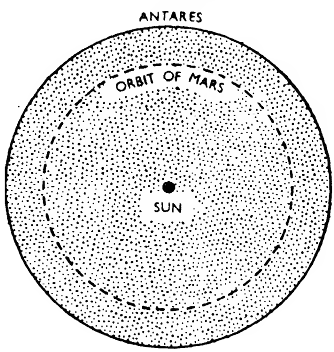


Fig. 6. *Relative sizes of the Sun, Antares and the orbit of Mars.*

Few stars have a mass greater than fifty times or less than one-tenth the mass of the Sun. There proves to be a very close connexion between mass and luminosity, the stars of highest candle-power being the most massive; and conversely. The large, massive and highly luminous stars are called giants: the small stars, of small mass and low luminosity are called dwarfs.

The mass of Neptune is only about one twenty-thousandth that of the Sun. A star which is smaller than Neptune and which has a mass not much less than that of the Sun must therefore have a very high average density. The stars differ more widely in density than in any other respect: the average density of a giant star such as Antares is comparable with that of air in a fairly well exhausted vacuum, whereas some of the dwarf stars are so dense that a match-box full of their material would weigh several tons.

The knowledge of the structure of the atom, which has been gained in recent years, shows how such extremely high densities are possible. An atom can be crudely compared to a miniature solar system, with a central nucleus, around which move a number of electrons. The total volume occupied by the nucleus and the electrons is very small compared with the size of the atom. At high temperatures the electrons become successively detached from the nucleus; the temperature inside a star is so high that all the electrons become detached and we have a vast collection of nuclei and electrons flying about independently of each other. It thus becomes possible to compress the matter to a state of extremely high density, in which the electrons and nuclei are brought very close—a density which is much higher than that of any solid at normal temperatures.

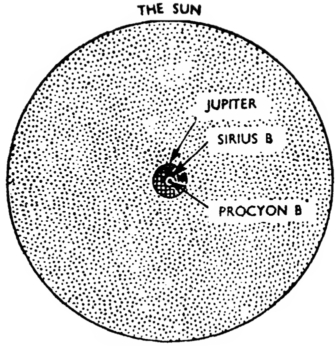


Fig. 7. *Relative sizes of the Sun, Jupiter, Sirius B and Procyon B.*

The composition of the stars can be investigated by analysing their light, just as in the case of the Sun. Not only are the elements in the Sun found to be present also in the stars, but the various stars appear to be remarkably similar in their composition. By far the most abundant element in the stars is hydrogen; although this is the lightest element, it forms about one-third part by weight of the average star. This similarity in composition suggests that the stars may all have been formed by condensation from some primeval material that at one time filled all space.

Double and Variable Stars

Many stars which appear single to the unaided eye or when viewed in a low-power telescope are found to be double when viewed in a high-power telescope. The appearance of a double star may, of course, be due merely to two stars lying by chance almost in the same line of sight; but double stars are far too

numerous to be explained as such a chance effect. The majority of stars that appear double are real twin systems; this can be confirmed by careful observations, for it is found that the two twins of the system are moving round each other. Thus the stars, equally with the planets, their satellites, and comets are obedient to the law of gravitation. It is from the study of the orbital motions in these twin systems that much of our knowledge of the masses of the stars has been obtained.

If we were to view such a twin system edgewise or nearly edgewise-on in the plane of their motion, each star would eclipse or partially eclipse the other once in each orbital revolution. The brightness of the system will change as the light from the one star is partially or wholly cut off by the other. Many stars are found to vary in brightness in a regular way, which can be accounted for by mutual eclipses; such stars often appear to be single even in the highest powered telescopes, but the variations in brightness tell us that they are really twin systems.

Stars which vary in brightness are called variable stars. In most cases the variations in brightness are not due to eclipses in a twin system but are real variations in the brightness of a single star. The changes of brightness of many stars are quite irregular. But there is one class of star of special interest in which they occur with remarkable regularity. These stars are called Cepheid variables, after the type star Delta Cephei.

The variations in brightness of the Cepheid variables have been proved to be caused by rhythmical pulsations of the star as a whole, so that these stars are often called pulsating stars. Their special interest arises from the fact that a definite relation exists between the intrinsic brightness of the star and its period or length of time of pulsation. The greater the brightness of the star, the longer is its period of pulsation.

As it is a straightforward matter to determine the period of the variation in brightness, the intrinsic brightness or candle-power of a Cepheid variable can readily be calculated. The Cepheid variables therefore serve the astronomer as standard candles, for by measuring the apparent brightness of such a star and knowing its intrinsic brightness, we can readily calculate its distance.

This property of the pulsating stars is of special importance because these stars all have great intrinsic brightness and they are visible at a very great distance, so that they enable the distances of remote objects or systems to be found. As the direct measurement of star distances becomes unreliable beyond about 500 light-years, the pulsating stars enable the astronomer to extend his knowledge of stellar distances considerably.

"New" Stars

Another group of stars of special interest are the novæ or new stars. A nova is a star which, after behaving as a normal star, suddenly commences to increase rapidly in brightness and in the course of a few days or even of a few hours increases in brightness a hundred thousand or even a million fold. A star which was invisible to the naked eye may increase in brightness to such an extent that it becomes visible. Before the days of the

telescope, it appeared when this happened as though a new star had appeared in the sky; such a star was consequently called a new star

A particularly bright nova appeared in 1572 and became as bright as Venus at its brightest; it was extensively observed by Tycho Brahe. After a nova has reached its maximum brightness, about 80,000 times the brightness of the Sun, the nova starts to fade again, at first rapidly and then more slowly, until it at length returns to approximately its former brightness.

When the outburst of a nova occurs, the star swells up rapidly and, when near its greatest brightness, throws off a shell of gaseous matter which moves outwards from the star with a high speed, usually several hundreds of miles a second. These shells of gas, still receding from the nova, can often be photographed many years after the outburst. The cause of the outburst of a nova is very much of a mystery. The high luminosity of these stars at their maximum brightness proves useful in providing another means of estimating the distances of very remote systems, because, taken by and large, the luminosity of all novae at their maximum seems to be approximately the same.

Movements of the Stars

The ancient Greeks called the stars fixed stars to distinguish them from the wandering stars or planets. Being without any means of making measurements of great precision, they were unable to detect any changes in the relative positions of the stars. In 1718, Halley found that the bright stars Arcturus and Sirius had moved southwards since the time of Ptolemy, about the middle of the second century A.D., by about 1 deg. and ½ deg. respectively. Since Halley's time, the accurate measurements of star positions have shown that no stars can properly be called fixed. The stars are all in motion and it is only because their distances are so great that these motions remained so long undiscovered.

The motions of a star in space may be in any direction. The motion at right angles to the line of sight causes an angular change in the position of the star; if the star's distance is known, this change can be converted into a speed of so many miles a second. The motion in the line of sight can be directly measured in miles a second, because it produces changes in the colour of the light emitted by the star. The stars of small mass move on the whole more rapidly than the stars of large mass; in this respect the stars behave rather like the molecules in a mixture of gases, where the molecules of the lighter elements move faster on the average than those of the heavier elements.

The motion of the Sun itself can be detected by analysing either the angular motions of the stars across the line of sight or the linear motions along the line of sight. The Sun proves to be moving, relatively to the surrounding stars, with a speed of about thirteen miles a second towards a point in the constellation of Hercules.

The Galactic System

The first attempt to obtain information about the general structure of the stellar or sidereal system was made by Sir William Herschel in the latter part of the eighteenth century, using his method of star-gauging. Herschel took some 700 regions distributed over the sky and

with his telescope counted the number of stars visible in each region. He assumed that the depth to which the sidereal system extended in any direction was proportional to the number of stars visible in that direction. The conclusion he reached was that the system was shaped roughly like a gigantic grindstone, with a much greater extension in all directions in one plane than in any other direction.

The Milky Way

The plane in which the greatest extension of the system occurs is marked by the Milky Way, the broad bright belt which stretches right round the sky. Before Herschel's time there had been much controversy about the nature of the Milky Way. Herschel's telescope, of much better quality than any previously constructed, showed conclusively that the Milky Way consists of a vast number of faint and presumably distant stars; invisible separately to the naked eye, the aggregate brightness of the great number of stars is considerable.

With large modern telescopes, the Milky Way can be studied in great detail. It has an irregular structure and consists of numerous groups of stars, called star-clouds. The brightest region, containing the densest collection of stars, is in the constellation of Sagittarius, in the southern sky. For part of its extent, the Milky Way (see Plate III) divides into two branches, separated by a region comparatively devoid of stars. The star-clouds are all very remote: they contain many pulsating stars, which enable their distances to be determined. Some of them are at distances as great as 30,000 light-years; other star-clouds which are hidden from view by nearer clouds are presumably still more distant.

In many parts of the Milky Way we find not only stars but also hazy patches of faint greenish light. The most powerful telescopes fail to resolve these patches into separate stars and the analysis of their light proves it to be the same as the light given out by luminous gas. These luminous patches, or nebulæ (from the Latin word for "cloud") consist of gaseous matter of extremely low density, not more than one-millionth that of the gas left in the most perfect vacuum that the physicist can produce. They shine by virtue of stars embedded within them, absorbing the light from the stars and emitting it again.

In addition to these luminous clouds, many dark patches, almost devoid of stars, are found in the Milky Way, occurring often in close association with the luminous nebulæ. These dark patches are caused by opaque clouds of fine dust which obscure the light from the stars lying behind. This fine dust is widely scattered throughout the central regions of the Milky Way; the division of the Milky Way into two branches over part of its length, already referred to, is due to the presence of this dust. The absorbing matter in the Milky Way regions is a serious complication to the astronomer, because even where it does not completely black out most distant stars, it dims them and complicates the determination of their distances.

Globular Clusters

How then is it possible to form any reasonably accurate idea of the dimensions of our sidereal universe or Galaxy, as it is generally called? This is, fortunately made possible

by a group of objects of special interest, called globular clusters. Such a cluster consists of a more or less spherical group of many thousands of stars, packed more and more closely towards the centre of the cluster. Unlike the discrete stars, which are strongly concentrated towards the plane of the Milky Way, these clusters have an approximately spherical shape so that, for the most part, they are not viewed through any great depth of absorbing matter. Their distances can all be found, because pulsating stars are present in them. They prove to be very distant systems, the nearest of them being approximately 15,000 light-years away.

Characteristics of Galaxy

With the information obtained from the globular clusters, supplemented by other information, it has been found that the Galaxy is a highly flattened system whose greatest extent, in the plane of the Milky Way, is about 80,000 light-years (see Fig. 8). Our Sun occupies a position, about 25,000 light-years from the centre, which lies in the direction of the star-clouds in

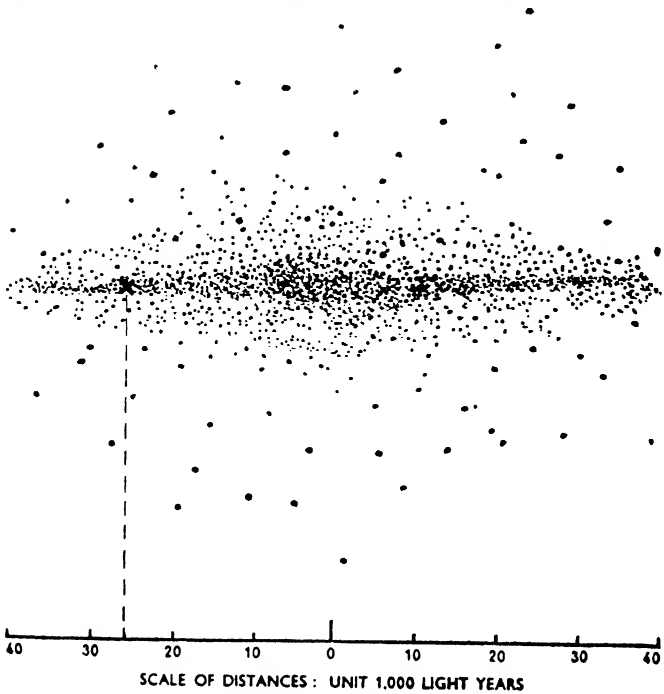


Fig. 8. *Schematic model giving the shape and dimensions of the Galaxy. The small dots represent stars and the larger ones globular star clusters. X = the position of the Sun.*

Sagittarius, where the Milky Way is brightest. The study of the motions of the stars in the direction of, and away from, the centre, shows that the Galaxy is slowly rotating, the time of one complete rotation in the neighbourhood of the Sun being about 225 million years. Yet, because of the great dimensions of the system, the Sun, in common with the stars in its vicinity, has a motion through space, arising from the rotation, of about 130 miles a second.

The rotation takes place under the general gravitational attraction of the system as a whole, which enables the mass of the system to be estimated. It proves to be about 160,000 million times the mass of the Sun. This mass includes the mass of all the stars together with that of all the gaseous matter and dust scattered through the system; the total mass of this diffuse matter is approximately equal to the total mass of all the stars. Thus about half the matter of the Galaxy has condensed into stars which, if all were of mass equal to the Sun, would number about 80,000 millions; the other half has remained uncondensed.

Other Galaxies

Our Galaxy is merely one of many other galaxies or island universes in space. Many systems are known which resemble in all their essential features what we may suppose our Galaxy would look like, if seen edgewise-on from a great distance—elongated systems with a central condensation and with obscuring matter spread along the central plane. But what would such systems look like if seen broadside-on? Systems can be found which are inclined at all angles to the line of sight from edgewise-on to broadside-on. When seen broadside-on these galaxies show a typical spiral structure, with two spiral arms curling outwards from the central nucleus (see Plate II). For this reason they are often termed spiral nebulæ. The extent to which the matter in the arms has condensed into stars varies from one galaxy to another, but many appear to be in a state of aggregation corresponding to our Galaxy.

The Great Nebula in Andromeda, which is visible to the naked eye as a faint diffuse patch of light, can be studied in considerable detail. It contains numerous star-clouds, bright nebulæ, obscuring matter and star-clusters; both Cepheid variables and novæ have been detected in it. Like our Galaxy it is slowly rotating. There is a strong general resemblance between the structure of the Andromeda nebula and our Galaxy, but before it could be concluded that they were similar systems the dimensions and distance of the Andromeda nebula had to be determined.

For many years it remained undecided whether the spiral nebulæ were members of our Galaxy or were island universes; they were found in all parts of the sky except in the vicinity of the Milky Way. This seemed to indicate a distribution related to the structure of our Galaxy, but we know now that it is the obscuring matter in the Milky Way which makes it impossible to see distant systems which lie near the plane of the Milky Way.

The discovery of Cepheid variables and of novæ in the Andromeda nebula and in several other of the spiral nebulæ enabled their distances to be found and their

dimensions to be assigned. The distance of the Andromeda nebula was found to be 753,000 light-years, which places it far outside our Galaxy; in size it proves to be comparable with, though rather smaller than, our Galaxy. The other spiral systems in which Cepheid variables or novæ have been detected prove to be of about the same size. Rough estimates of the distances of more remote systems could therefore be derived on the general assumption that all these systems are equal in size.

The Expanding Universe

When the velocities in the line of sight of these other galaxies were measured, the unexpected result was found that they are all receding or moving away from our Galaxy and that their speeds of recession are roughly proportional to their distances. By assuming that the speeds of recession are strictly proportional to the distances, revised values of the distances were derived. The relationship between speed of recession and distance makes it possible to find the distance of any remote galaxy by measuring its speed of recession.

These stellar universes are to be seen in all parts of the sky in great numbers, except where they are hidden from our sight by the obscuring clouds in the Milky Way. It is estimated that in the whole sky about 75 millions of these universes could be photographed with the largest telescope available—the 100-inch telescope of the Mount Wilson Observatory. Many more will be within reach of the great 200-inch telescope, now under construction, for there is no evidence of any thinning out of these universes at the extreme depths of space to which the 100-inch Mount Wilson telescope can reach.

Universes are known which are at a distance of about 500 million light-years; a universe at this distance has a velocity of recession of about 53,000 miles a second—nearly one-third of the velocity of light. We can realize dimly the vastness of space if we remember that while the light from such a universe has been travelling towards us, dinosaurs and flying reptiles have appeared on the Earth, and with the slow march of time have disappeared again. Many of our mountain ranges have appeared and the face of the Earth has undergone considerable changes. Man did not appear on the Earth until the light was near the end of its long journey —a mere million years or so ago.

If the other universes are moving away from us with speeds which are proportional to their distances, this seems to imply that the scale of the Universe as a whole is progressively becoming greater or, in other words, that the Universe is expanding. The other galaxies are not merely receding from us, they are all receding from one another. If we could be transferred to another galaxy, we should still find that all other galaxies were receding from us. If we think of a number of ink dots being marked on a rubber balloon which is then inflated, it will be evident that the distance between any two dots becomes greater as the balloon increases in size. Whichever dot we choose, all the other dots appear to be moving away from it.

The expansion of the Universe is taking place at such a rate that all distances are doubled in about 1,300 million years. This period is long, judged by ordinary human

standards; but from the astronomical standpoint the expansion must be regarded as rapid. The age of the Earth is some 3,000 or 4,000 million years, so that during the lifetime of the Earth the dimensions of the Universe have doubled or trebled.

Astronomers have sought by various lines of investigation to determine the age of the stars. The evidence points to the stars not being more than about 10,000 million years old. If we go back so far in time the Universe was very much smaller than it is now. It has been suggested that originally the separate galaxies formed one system which at some instant exploded, the fragments being shot outwards in all directions. If this happened, then, at some subsequent time, the fastest moving fragments would have travelled out to the greatest distances; the whole system would appear to be expanding. Wherever we might find ourselves in this exploded system, every portion would appear to be moving away from us and we should have no means of identifying where the centre of the system was. We do not know, of course, what determined the zero hour of the system, nor why all the fragments should be of about the same size.

Colour-Change Theory

It must be admitted that this is all conjecture. There is an alternative view possible. The measures of the speeds with which the galaxies are moving away are based on the colour of the light received from them. If the colour of the light changes slowly in the course of its long journey through space, the light received from the most remote systems will have undergone the greatest change in colour. The effects would be indistinguishable from those produced by an expanding universe. So it is well to bear in mind that the interpretation of the observed colours as the effect of velocities of recession may not be the correct one. There are many problems in astronomy on which a final verdict cannot yet be given; in course of time, no doubt, new light will be thrown on many of these and much that is now obscure will eventually become clear.

The Unfinished Picture

The first star distance was not measured until 1838, and progress in the knowledge of stellar distances was slow until the application of photography in the early years of the present century. The use of the pulsating stars as standard candles made it possible for the real dimensions of our Galaxy to be estimated. These dimensions were at first over-estimated, because the important part played by the obscuring matter in dimming the light from distant objects was not realized until later.

The question whether our Galaxy was the whole Universe or whether the spiral nebulæ were distant island universes in space was solved by the great 100-inch telescope at Mount Wilson, which was completed in the First World War. We now know that our Galaxy is merely one amongst many millions of other galaxies. There is little evidence of any thinning out of these galaxies at distances of the order of 500 million light-years. We have reached the limits of our present canvas and the picture remains unfinished; to paint in the more distant scene is one of the main tasks that lie ahead.

CHAPTER 4

THE SCIENCE OF LIFE

Division of living organisms. Characteristic features of plant life. Nature of protein. Interdependence of plants and animals. Vegetative reproduction. Sexual reproduction of plants. Species and distribution. Basis of life. Protoplasm. Structure and properties of cells. Nerve nets. Cœlenterates. Segmental animals. Evolutionary characteristics of animals. Recapitulation theory. Fertilization of the ovum. Childbirth. The skeleton. Muscle and source of muscle power. Skin, hair, and epithelial tissue. Circulatory, respiratory, urinary, digestive, and nervous systems. Sensory apparatus. Species and varieties. Evolution. Man's vestigial charactistics of inheritance. Origin of species. Mendel's theory. Relation of biology to society. Practical aspects of biology. Theoretical aspects of biology.

THE scientific study of life is called biology, and it should, strictly speaking, include in its purview the consideration of every living organism, from the simplest to the most complex. It should deal adequately with their origins and powers of growth and reproduction, the chemical changes which go on within them, how and where they obtain their food, what they do with this food, how they live in association with other living organisms, and the functions of the different parts of their bodies—in fact, their life as a totality. Moreover, Man himself is a living organism, and so is an object of study by the biologist in all his reactions to the world outside, and also inside, himself.

If we take a comprehensive view, Man's evolution, prehistory, history, sociology, psychology, religious beliefs and so on are all really a part of biology. This would make biology such a vast subject that it could not possibly be grasped by any one understanding. Consequently, the term biology has come to be restricted to the study of plants and animals, leaving very much on one side for the study of specialists one of the most complicated of living organisms—Man.

In its generally accepted sphere biology follows three main lines of attack:—

(1) *Natural history*, or the observation of the different species of life in their natural surroundings.
(2) *Morphology*, or the description and classification of the different forms of life, and of the organs of all living things. (This work is often carried out on dead organisms, using dissection, microscopic technique and the like.)
(3) *Physiology*, or the description and explanation of the duties performed by the various parts of the organism studied, and of the organism as a whole.

The three modes of attack may be summed up roughly as: (1) How the organism behaves in natural

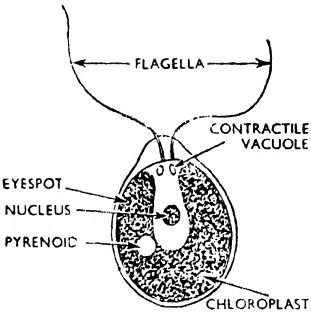


Fig. 1. *Chlamydomonas, a minute organism which swims about in fresh water during the summer.*

surroundings, (2) what it looks like, and (3) what it actually does.

Each of these lines is essential to a proper study of life. The morphologist in his laboratory, for example, may evolve a theory about

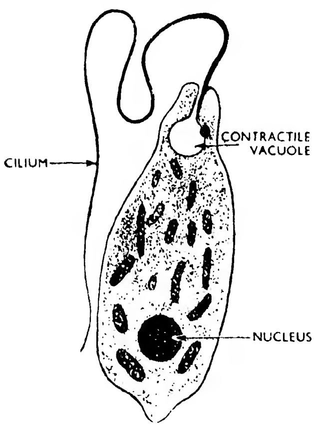


Fig. 2. *Euglena, a minute fresh-water organism which can either live like a plant by building up protein from substances in water or like an animal when it uses protein for food.*

the function of an organ which would be proved or disproved by a little natural history. Again, shape may, or may not, give a clue to function. Thus, a mass of regularly woven straw, with an indentation in it, might be guessed to be a bird's nest, but if we saw a woman wearing it on her head, the diagnosis would be "a hat." Generally speaking botanists have used all

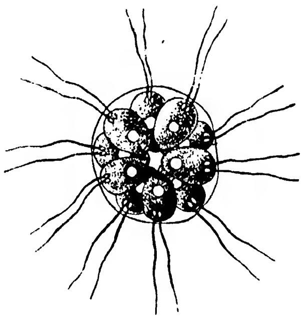


Fig. 3. *Pandorina, a colony of cells enclosed in a common membrane. Each cell has two flagella which propel the organism in fresh water.*

three methods in studying plants, but zoologists have tended to look askance at experimental work, except in the realms of genetics.

Classification of Organisms

The first big division of living organisms is into plants and animals. The former are studied by botanists, the latter by zoologists. Most people have a fairly clear idea of what they mean by a plant. It usually stands erect and is branched. It has green leaves, a root and stem, and it stays put—it has no power of locomotion. On the other hand, an animal is compact, may have any colour, and

can walk about. This is a good enough rough scheme for the average person. But then mushrooms and the bird's-nest orchid are plants which are not green, and there are animals which remain rooted to the ground, like the barnacle in its grown-up stage. Moreover, there are green organisms which have marked powers of locomotion, such as *Chlamydomonas* (see Fig. 1), *Euglena* (see Fig. 2), *Pandorina* (see Fig. 3) and *Volvox* (see Fig. 4) — all plants studied by botanists.

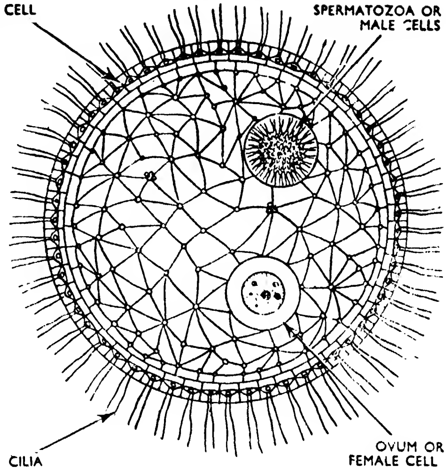


Fig. 4. *Volvox, another minute fresh-water colony of unicellular organisms enclosed in a common membrane. It employs the same means of locomotion as Pandorina.*

The most fundamental difference between plants and animals is really in their modes of nutrition. Plants take the mineral elements in simple inorganic form (nitrates, carbonates, and sulphates of lime, magnesium, sodium and potassium) direct from soil or water, and their oxygen and carbon dioxide from the air, and build up from these such complex organic matter as sugars, starches, cellulose, fats, proteins, and vitamins, whereas animals are obliged to get all these essential substances manufactured for them. No animal can manufacture sugar from carbon dioxide and water, nor can it manufacture all the vitamins. Animals rely on having all these things ready made for them by plants. But even this physiological difference between plants and animals breaks down as a means of classification in certain border-line cases. One yeast can be satisfactorily grown on a solution of simple mineral salts, with ammonium tartrate as the only organic substance present, while some near relatives (brewer's yeast, for example, see Fig. 5) need several complex vitamins for life and growth.

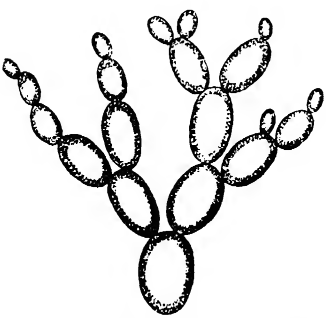


Fig. 5. *Brewer's yeast, a minute colony of cells which are essential in the process of making beer.*

Can some yeasts be plants, then,

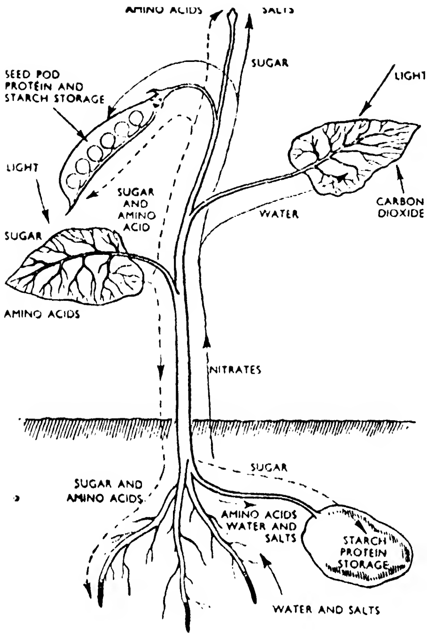


Fig. 6. *Highly schematized drawing showing the essential characteristics and functions of plant life and growth (see text).*

used completely to distinguish plants from animals. We must take all three factors into consideration and even then there will be found to be borderline cases. Are yeast and bacteria plants or animals? It does not really matter much.

What is clear from the discussion above is that characteristic plant life is essential to animal life, and (if we accept the story of evolution) must have appeared on this earth before animal life was possible. Plants can take simple inorganic substances and build them up into the complex organic materials essential for the life, growth and reproduction of animals. How do they do it?

To make complex substances like starch from carbon dioxide and

and their cousins animals? There are also plants (like the mushrooms, and the coral root orchid) which grow only on decayed complex plant material. Others (such as the mistletoe and dodders) draw part or all of their complex food from a host plant on which they are parasites, and still more, such as the sundew and the butterwort—quite obviously plants to the lay eye—which actually catch animals (see Fig. 14) and eat them for their protein!

We thus see that what an organism looks like, whether it moves or not, or the manner in which it gets its food, cannot be

water needs energy. The same is true of the manufacture of proteins, which most plants make from nitrates, carbon dioxide and water. Members of the bean and pea family utilize the nitrogen in the air, with the help of microbes inhabiting nodules on their roots, and thus make their own nitrogen fertilizer first. For such changes the plant needs energy from without, and it gets this energy from the sunlight.

Plant Chemistry

Let us look at any ordinary plant. Fig. 6 shows a highly simplified diagram of a plant. It consists of stem, root and leaves, with (in this

instance) a massive storage depot for the things it makes. It spreads out its leaves to catch the sunlight, absorbs the mineral substances and water that it wants by its roots, and is provided with a system of tubes and pipes to carry the sugars and amino acids it makes from place to place within itself.

That the leaves manufacture starch by the action of sunlight (or, of course, daylight) can easily be proved. Traces of starch are readily detected, for it forms a blue-black compound with iodine. All that needs to be done is to cover a leaf with tin-foil, or other light-proof substance, pierced with some recognizable design, and to put the plant in the sunlight. Towards the end of the day, the green colouring matter in the leaf is washed out with alcohol, and the leaf is immersed in a solution of iodine. It is then observed that where the sunlight got through to the leaf there is a deep blue-black colouration, proving the presence of starch, but where the leaf was protected from the light there is no starch (see Fig. 7).

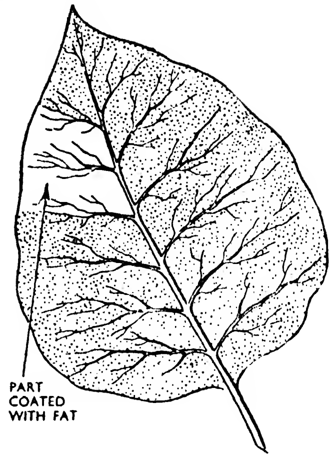


Fig. 8. *Carbon dioxide utilization. Part of the leaf has been smeared with fat, the whole exposed to sunlight and then stained with iodine. Where the fat prevented access of* CO_2, *no starch has formed.*

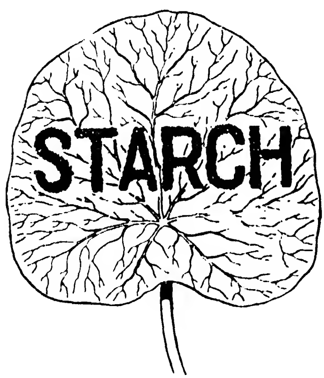


Fig. 7. *Starch formation in a leaf. The leaf has been covered with a stencil in tinfoil from which the word STARCH has been cut out. It has been exposed to sunlight for several hours, gathered, bleached and immersed in an iodine solution. Where the light has got at the leaf, starch has been formed—the letters blue-black on a whitish background.*

That carbon dioxide has been utilized can be shown by preventing that gas from reaching a part of a leaf and then treating it, after exposure to sunlight, with iodine. A simple way of preventing the gas getting at a part of the leaf is to smear the leaf with some fat. Where the fat has excluded carbon dioxide there is no starch (see Fig. 8).

Finally, it can be shown that the veins of the leaf are used to carry the starch away, after it has been manufactured, by cutting one of the

veins and storing the plant in the dark for a few hours. There is now no starch in the areas served by intact veins, but where the vein has been cut (and transport interrupted) there is still found to be an abundance of starch (see Fig. 9).

Sugar Formation

Starch is insoluble in water, and it is almost certainly changed into sugar when transportation has to take place. By day, starch is made in the leaves; by night it is carried away to a storage place, such as roots or stems, or modified roots (like carrots) or modified stems (like potato tubers). It can then be sent at any time to where it is wanted, say, for the manufacture of new cell walls, or as fuel for the production of warmth—for plants are warmer than their surroundings.

The flow down the stems during the night towards the roots, and upwards again during the day, in

Fig. 9. *Starch transportation. The central vein of this leaf has been cut. The next morning it is seen that all the starch has been drained away from the leaf except where the cut vein has made that impossible.*

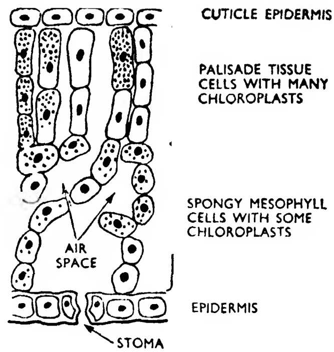


Fig. 10. *Section of a leaf, as seen through a high-powered microscope, to show the green bodies in the cells called chloroplasts.*

the sap of the plant, is made use of by man in making maple sugar. A hole is bored in the trunk of the sugar maple and the sap flows out into a tin affixed to the trunk. In Canada the best yield is in the spring months when the air is frosty at nights and the transport of material manufactured by day is at its greatest. This shows that starch is transported as cane sugar, a very soluble substance. A potato which has sprouted has a sweet taste due to the formation of sugar from the starch stored in the potato.

Seeking the Sunlight

The mechanism for trapping the rays of the sun is the green pigment, called chlorophyll, which gives the leaf and stem of a plant its characteristic colour. If we look at a cross section of a leaf through a microscope, we see in the cells (see Fig. 10) green bodies called chloroplasts. These contain the complex green pigment, which is chemically similar in many respects to the red

pigment of animal blood, but it has magnesium in its structure instead of iron. Iron must, however, be about for the plant to manufacture chlorophyll, and if there is not enough iron in the soil the plant suffers from a sort of anæmia, just as man suffers from anæmia if he does not get enough iron in his food. Chlorophyll is manufactured only in the presence of light. Underground stems are blanched, and when the gardener wants to blanch endive, celery or chicory, he excludes the light by heaping earth round the stems.

Plants deliberately seek light in order to manufacture chlorophyll and starch. Plants grown in the dark reach out long stems in search of light, and will turn towards the light even if it be very dim. A plant grown in a cellar may be found to have turned towards the light even of a candle. A plant grown in the dark weighs, when dried, no more than the seed from which it has grown, but one grown in daylight weighs double or more a short time after its first green leaves are formed.

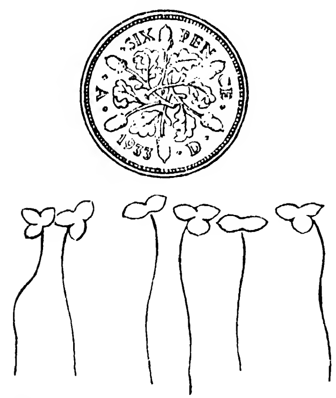


Fig. 11. *Duckweed. Diagram showing six plants of natural size compared with a sixpence. This is one of the smaller "naked eye" plants.*

This stretching out of plants excluded from strong light is used by the market gardener to produce long stems in forced rhubarb. Rhubarb which has thus been forced can be detected also by the colour of the leaves, which are yellowish instead of green. Plants from which light has been excluded become feeble from lack of chlorophyll and the market gardener is therefore careful not to force his rhubarb two years in succession.

One of the main characteristics of plant life, then, is the possession of chlorophyll, and that is why *Chlamydomonas*, *Euglena*, *Pandorina* and *Volvox*, organisms which freely swim about in water, are classed as plants rather than animals by the biologist.

Catching the Sunlight

The chief task of a plant is to get to, and spread out its leaves to catch, the rays of sunlight, and myriad are the ways in which different plants solve this problem. Duckweed (see Fig. 11) solves it in one way, and gigantic trees such as the giant redwood tree of California (*Sequoia gigantea*) solve it in quite another way. Within this enormous range in size we find innumerable other solutions of the problem. Shapes, sizes and dispositions of the leaf on the plant all vary. Every conceivable form and pattern of leaf has been exploited, and each must have some advantage for the plants to have survived till today through countless years. And every mode of getting to the light has also been utilized. Some plants build themselves internal girders of a woody nature which hold them

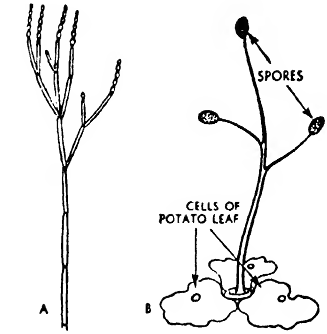


Fig. 12. *Two growths which do not form chlorophyll.* A—*Penicillium, from one type of which penicillin is extracted.* B—*Phytophthora infestans, a fungus disease of potatoes.*

sturdily upright into the air (herbaceous plants, bushes and trees); others float their leaves on the surface of the water (water lilies, duckweed); others again use the sturdy support of other plants and clutch them by means of small roots (ivy), tendrils (peas, white bryony, virginia creeper, vines), hooks (brambles, goose grass), suckers (*Ampelopsis Veitchii*), or by twisting round them (bindweed, runner beans, hops and lianes of tropical jungles).

It will be remembered that there are plants which form no chlorophyll, plants which can grow in the dark, like mushrooms. They make cellulose, yet get no energy from the sun directly. These plants use the dead and decayed matter of other plants. They have to wait on the growth, death and decomposition of chlorophyll-containing plants. Such are the jackals of the plant world. They have to rely on other plants to catch the energy from the sun by which ultimately all plants and all animals as we know them exist. These plants, however, have their purpose in nature as may be seen in any rotting heap of straw or leaf mould. Throughout the heap there may be found white filaments which some day may come together and form the structures we know as mushrooms, toadstools, truffles, penicillium (see Fig 12A) and the like.

Parasitic Plants

Some plants have become parasitic, either upon other plants or even upon animals. The dodder, for example, parasitizes heathers and brooms; while mistletoe parasitizes the oak, the apple and the poplar. Some fungi parasitize trees, such as the "poor man's beef steak" which grows on the elm; and the silver-leaf fungus which grows on the Victoria plum. Other fungi

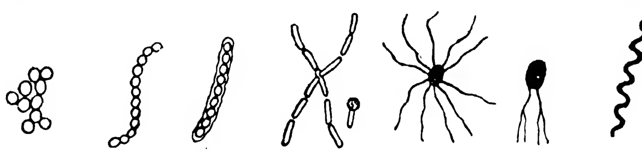


Fig. 13. *Some interesting species of bacteria:* A—*staphylococcus aureus (one of several types found in suppuratory wounds),* B—*streptococcus (one of several types which causes inflammation),* C—*pneumococcus (lobar pneumonia),* D—*anthracis (anthrax),* E—*eberthella typhi (typhoid fever),* F—*azotobacter (bacterium which fixes nitrogen), and* G—*spirochaeta (syphilis).*

parasitize the skin of man and animals (ringworm—which is "fairy rings" of fungus on the skin—athlete's foot, and, a most dangerous disease, namely, actinomycosis). Again we meet innumerable ways of solving the problem of continuance of existence among plants by parasitism. Nor must we omit to mention the bacteria which can, and do, parasitize plants and animals. We think of bacteria as the cause mainly of disease in man and animals: Fig. 13 being taken from that group. But bacteria have their uses: the weed heap would never rot to humus were it not for them. Some bacteria live on sugar and make the acid beers (Weissbier) of Germany; or on the sugar of milk and are important in butter, cheese and margarine manufacture. Bacteriology in the service of man, though in its infancy, has already many weighty volumes applied to its discussion.

Finally, we must not forget that some quite highly organized plants, though endowed with chlorophyll to catch the sun's radiant energy, prey upon animal life for their nitrogen (their protein), thus reversing the usual mode of animals preying upon plants. These plants trap and digest insects and among them may be mentioned two which grow in the boggy moors of Great Britain, the sundew (Fig. 14) and the butterwort. Warmer climates have the Venus fly-trap, the pitcher plants and others. But this is rather a byway in the plant world.

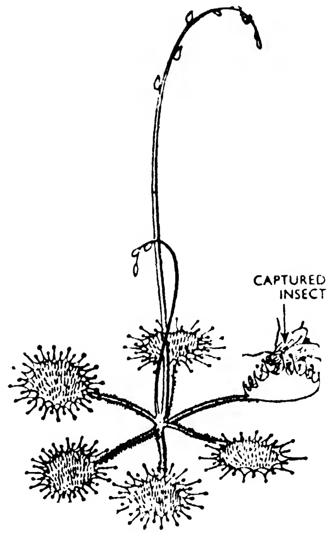


Fig. 14. *Sundew, which catches and eats insects to get protein.*

Nature of Protein

Protein is the basis of the structure of all plants and animals. It is a highly complex substance built out of simpler "building stones" called the amino acids. A plant takes nitrates from the soil, carbon dioxide from the air and with water manufactures first some twenty or more different amino acids. It then strings these together, somewhat as a necklace of beads are strung together, only the string is not something apart from the beads, but an integral portion of the beads (a daisy chain would give a better idea). When some fifty to two hundred amino acids are joined together we have a protein.

No living thing is known which does not use protein as the basis of its shape and form and structure and as a means of carrying out functions necessary to life. Meat (muscle fibres) consists largely of protein, beans have 25 per cent protein in them. Ferments, such as the enzymes of yeast which can turn sugar into alcohol, are proteins. Even the viruses are protein

in nature (viruses are the gap between dead and living matter; they are also the cause of some diseases in plants and animals, such as tobacco, potato, see Fig. 12B, and raspberry mosaic disease, and infantile paralysis in man). So the manufacture and uses of protein belong to the science of life.

Again the study of this branch of biology has proved vast and voluminous, and the interested reader is referred to works such as Jordan Lloyd's *The Chemistry of Proteins.* There are millions of proteins and every living organism contains proteins of a definite chemical stamp. Wheat proteins differ from animal proteins, the proteins of barley are different from those of wheat. But they are all alike in being built from amino acids and their differences are dependent upon the nature, the number and the arrangement of the different amino acids. Plants can manufacture

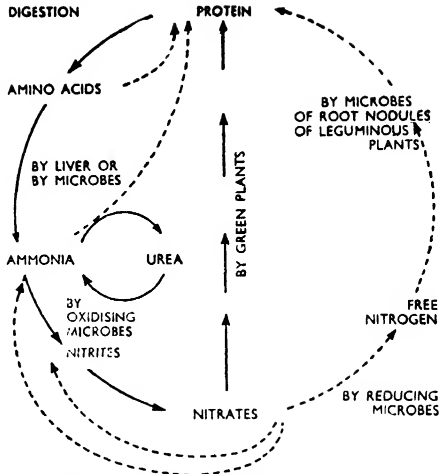


Fig. 15. *Schematic diagram of the nitrogen life-cycle showing the interdependence of plants and animals for protein. One type of microbe in the soil and another in the root nodules of leguminous plants convert the nitrogen in the soil into ammonia. This ammonia is eventually converted into nitrates, nitrites, etc., which are an essential food of green plant life. From nitrates and carbon dioxide these plants manufacture protein—an essential to animal life. Animals digest protein, and, subsequently, the amino-acids of protein are converted by the liver into ammonia and then into urea. Urea is normally returned to the earth, as is the decaying leaf matter of plants. The urea is converted by microbes into ammonia and, subsequently, oxidizing microbes convert this ammonia into nitrates and nitrites, and so on.*

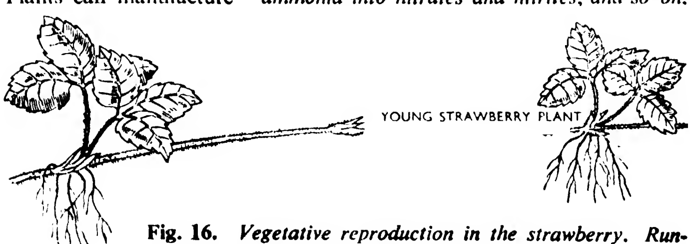


Fig. 16. *Vegetative reproduction in the strawberry. Runners are sent out which form small plants at their ends.*

Fig. 17. *Vegetative reproduction in the bramble. Like the strawberry, runners are sent out and these attach themselves to the ground, form roots and, subsequently, a new plant.*

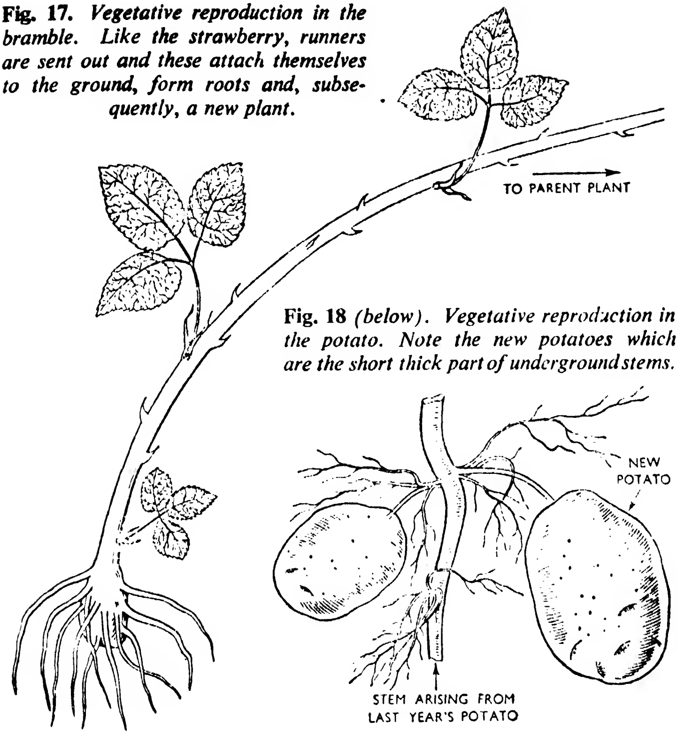


Fig. 18 *(below). Vegetative reproduction in the potato. Note the new potatoes which are the short thick part of underground stems.*

the necessary amino acids from carbon dioxide, nitrates and water. Animals cannot. So plant life is essential to animal life. Animals must prey upon plants to continue their existence.

The interdependence of plants and animals for protein is indicated in Fig. 15 which shows what has been called the nitrogen cycle. The diagram is worthy of close study by anyone interested in the science of life. The main difference between living and dead matter is that living matter can grow, propagate and reproduce itself. Dead matter cannot. This is a commonplace. If you take some soil and sterilize it and keep it out of contact with sources of life, it remains for ever dead. But leave it in the open air and light and it is soon a happy hunting ground of all sorts of plant and animal life, as the gardener knows to his cost. The debris of the bombed areas nourished willow herb, sow thistle and a host of other plants, which have succeeded in capturing the sites by paratroops.

Vegetative Reproduction

Plants reproduce themselves in two ways: vegetative and sexual. The vegetative way is by means of setting aside parts of themselves which, becoming detached from the

parent plant, carry on a separate existence. *Chlamydomonas* (see Fig. 1) simply divides into two. Where there was one *Chlamydomonas* there are now two, and so on *ad infinitum.* In ordinary husbandry we see something similar in the strawberry plant. This sends out runners (see Fig. 16). The little plant at the end of the runner makes roots, attaches itself to the soil, and ultimately becomes a self-supporting new plant (the Royal Sovereign strawberries today are survivors of the offsets of a plant originally produced in Queen Victoria's reign). In the lifetime of the writer the wild strawberries of his schooldays have invaded a neighbourhood a mile or more distant from their point of origin and climbed some hundred or more feet up a hillside. The bramble has a similar mode of vegetative reproduction (see Fig. 17). Left to itself it will invade whole agricultural areas and render them useless for husbandry.

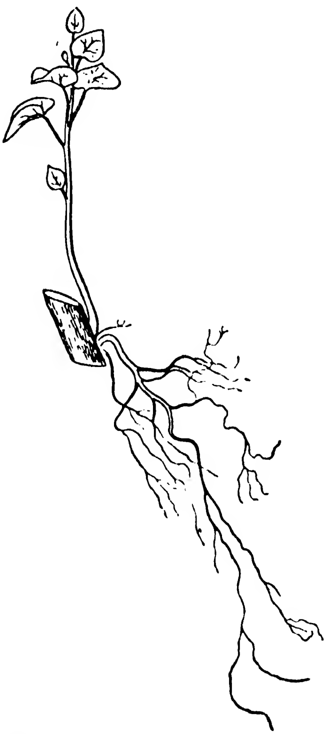


Fig. 19. *Vegetative reproduction in bindweed. This is a natural-size drawing of a young plant which grew from an accidental cutting.*

Sometimes plants reproduce themselves by underground stems (such as the iris, twitch grass, thistle) by forming modified stems and buds which get detached from the parent and start a new plant (potato, see Fig. 18, crocus, tulip), or by modified leaves (onion, lily). Some have learnt to form new plants from roots (elm, bindweed). This latter dastardly little plant can grow a new plant from less than an inch of root (see Fig. 19) and this makes it particularly obnoxious in a garden. The power of plants to reproduce themselves vegetatively is utilized by gardeners through cuttings and layers, in growing potatoes, shallots, garlic, tulips, hyacinths, irises, crocuses and other bulbous plants.

Sexual Reproduction

Although some plants, such as the banana of cultivation, rely entirely upon such asexual methods of propagation, most plants have also a sexual mode of reproduction. In sexual reproduction a tiny unit portion of an organism called a cell is freed to unite with a similar cell of another part of the organism or from another organism of the same type. The two cells fuse, often pass into a resting stage, and finally grow into a new and independent

organism. The original has reproduced itself. Sometimes one of the cells is motile and is called the sperm and the other is sessile, and is called the ovum, or egg cell; but in lowly plants such as *Chlamydomonas* the two cells are indistinguishable. That flowering plants have sexual modes of reproduction was obvious even in the earliest days of science. Gardeners today are aware that if they have no male *Skimmias* to fertilize the female *Skimmias* there will be no autumn harvest of red berries which are the chief reason for cultivating the plant. Flowers are the sexual organs of plants, and usually both male and female organs are found on the same plant—the stamens (male) and the stigma, style and ovary (female) (see Fig. 20). The stamens produce pollen, which is carried by wind or insects to the stigma; on the stigma, the pollen grain grows a long tube down the inside of the style, and a cell (non motile, but nevertheless a male cell) at the end of this tube passes into the ovary and there unites with an ovum or egg cell in that ovary (see Fig. 21).

The union proceeds to develop a seed. This seed is a tiny embryonic plant with root, stem and leaves already sketched out, covered in a semi-waterproof coat, almost dry, and ready to withstand the cold of winter or the drought of summer, and ever ready to germinate should it find conditions of moisture and temperature suitable (see Figs. 22 and 23).

For the extremely ingenious ways in which plants ensure the transport of the pollen to the stigma or to get the advantage of cross fertilization from the stamen of one flower to the stigma of a distant plant the reader must be referred to botanical textbooks. The cleverest modes have been invented by the orchids, and the most effective by the daisy

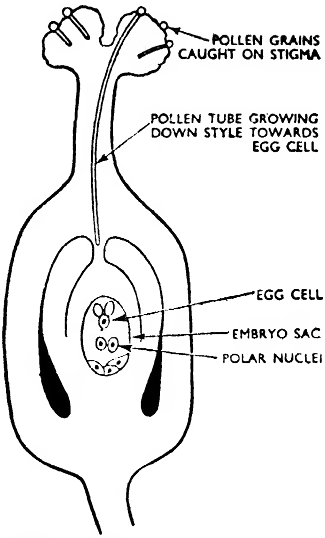


Fig. 21. *Stigma, style and ovary of a flowering plant like a lily (longitudinal-section) to show pollen tubes growing down from the pollen grains on the stigma towards the egg cell situated in the embryo sac.*

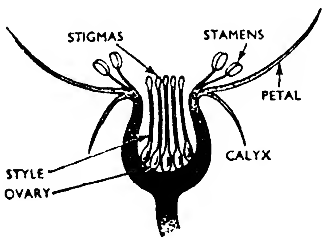


Fig. 20. *Rose flower (cross-section) to show the reproductive organs (stamens, stigmas, style, ovary), and other associated parts.*

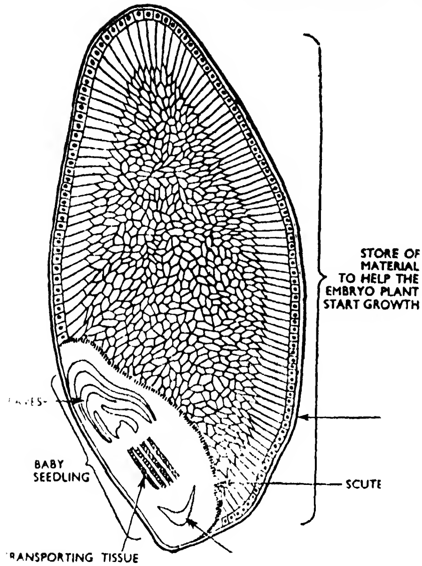


Fig. 22. *Wheat seed, in section to show seedling.*

family, the Compositae, which have hit on the plan of putting hundreds of little flowers all close together on one head so as to form a single "flower" (see Fig. 24).

Species and Distribution

The daisy-dandelion-yarrow-groundsel-chrysanthemum family have beaten all the other families in wealth of species and distribution over the earth. The orchids may be the *Herrenvolk* of the plant world, but the meek daisy tribe have inherited the earth. The modes of distributing seeds are also intensely ingenious. Some, the most successful in colonizing new quarters, attach parachutes to their seeds (willow herb, dandelion, see Fig. 25, thistles) for the wind to carry about; other seeds are shot as from a catapult (balsam, broom); others again are sprinkled from a pepper pot (poppies, see Fig. 25); still another kind of seed sticks to the coats of animals (burdock, goose grass, see Fig. 25). Infinite are the ways of plants in distributing their seeds, and most amazing!

Some plants, too, possess what is called an alternation of generations. The fern plant on the rockery possesses no sex. It drops on the earth bits of itself, each of which proceeds to grow into a tiny plant called a prothallus, quite unlike the fern. This in turn develops male and female organs and is the sexual generation of the fern. A sperm cell unites with an ovum, and from the fusion arises a new fern—the asexual generation. In the case of the mosses, the big plant is the

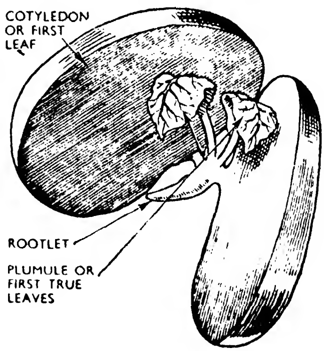


Fig. 23. *Runner bean seedling with the hard outer coat removed, showing the developing plant's cotyledon, first true leaves and rootlet.*

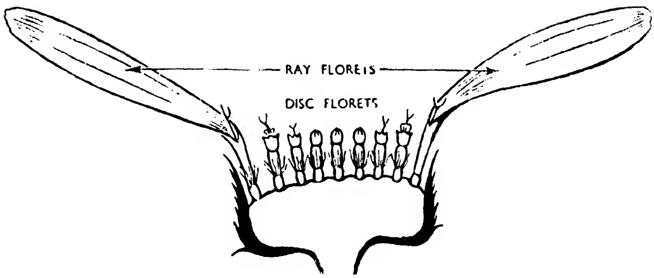


Fig. 24. *Daisy family type of "flower," which is really a collection of flowers. The ray florets usually bear female organs only, the disc florets have both, but the male parts ripen before the female. One insect tramping round can transfer pollen from all the ripe stamens to all the ripe stigmas.*

sexual generation and those other queer little cap-like bodies the asexual generation.

It is impossible to escape a belief that all plants of today had a common ancestor some 500 million years ago. It was simple and lived in water like *Chlamydomonas*. Each organism lived for itself alone and did everything such as assimilation of water, carbon dioxide, mineral salts, built up cellulose and protein and reproduced. Later, it may be imagined that a colony of individuals such as in *Pandorina* and *Volvox* had its advantages and species of this type gradually developed. This involved a division of labour—some cells being set aside for reproduction for example, as in *Volvox*.

Further development along these lines can be illustrated by the seaweeds, where one part of the plant is detailed for anchorage, another for catching light and a third for reproduction. Cells are set aside, too, for transport within the plant, from point to point.

Then came the invasion of the land surfaces of the earth via the swamps. Before land could be colonized by animals it had to be colonized by plants, and for this the plants had to grow roots to get material from the soil and leaves to catch the sunlight. They had to produce a better internal transport

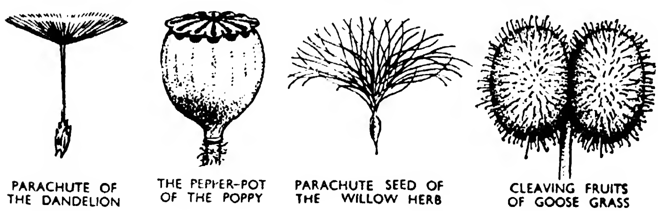


Fig. 25. *Four plants which employ ingenious methods for the disposal of their seeds. Perhaps the most interesting is goose grass which attaches itself to the coats of animals and is transported from place to place (see text).*

system between roots, stem and leaves. Further, they had to protect themselves against drying up, and manufacture cuticle, cork and bark. Then they had to stiffen themselves to fight wind and gravity and to do this they produced wood. Finally, for their offspring, to tide over seasonal changes in weather conditions, they had to invent seeds. This they had managed already before the carboniferous age—the coal age—but by the advent of that time they had reached a luxuriant development of giant club mosses, giant horsetails (from which the humbler club mosses, and the horsetails of today, are descendants), ferns and seed-ferns (now extinct and found in fossil form only).

Conifers (pines, firs, larches, etc.) had not been developed, and flowering plants—the mainstay of today's agriculture and horticulture—had to wait for their development till the chalk age, say 50 million years ago. Taking the evidence of geology, together with the embryology and comparative anatomy of plants, we can best sum up what we learn by assuming that there has been an orderly evolution of plants from simple forms like the water-inhabiting *Chlamydomonas* up to land-inhabiting flowering plants. How this came about, and whether we believe it is absolute truth and not merely a convenient hypothesis, is a question to be decided by philosophers and theologians.

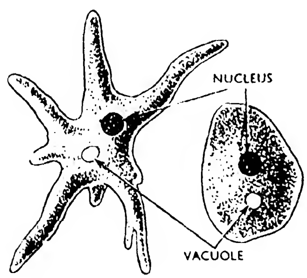


Fig. 26. *Amœba. On the right, it is shown resting; on the left, it has thrown out false legs (pseudopods)—one of these pseudopods is used for anchorage to some object that comes within its reach (see text).*

Animal Life

It has been assumed above that all plant life has evolved from a simple primordial speck of living matter swimming or floating in sea water, by formation of colonies, division of labour between their members, development of specialized organs for individual purposes, etc., till there arose the whole range of plants from minute algæ to giant trees and flowering plants. The same assumption we shall make about the evolution of animals. They arose by incredibly slow stages from simple acellular organisms something like the amœba and by similar steps arose the multitudinous forms of animal life including Man. This theory is the simplest we can make; it accords with the evidence of geology, though there are gaps in the record; it is confirmed by biochemistry; it clarifies the embryology—the development of the animal from fertilization till birth—of animals, both in whole and in part; it explains so much which otherwise would seem purposeless and obscure; it enables the biologist and others to think rapidly and clearly and to relate all the phenomena they study to one comprehensive plan. This is not, of course, to say that it is true, and if the theologians prefer to believe in myriads of acts of creation carried out so as to simulate evolution, that

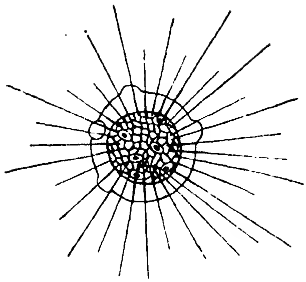


Fig. 27. *Sun animalcule, a minute organism with motile hairs projecting radially from its surface; these are employed for catching its prey.*

is their lookout. It is a much more complicated theory and is therefore more unmanageable.

The Basis of Life

First, we must try to imagine how the basis of life arose. It probably was a small blob of transparent fluid rather like jelly or glue. We see it in the simplest plants and animals (as well as in the complex) and call it protoplasm—"that which was moulded first." This protoplasm is already complex. It contains much water (60 or 70 per cent or more) and in this water are complex colloid substances called proteins.

The proteins, as recounted above, consist of aggregates of twenty-two different amino acids, and there is the possibility of there being millions of proteins, for there are 10^{48} (10 billion, billion, billion, billion) different ways of putting a very simple protein together from twenty amino acids.

More complicated proteins are found in the nucleus (see Fig. 26), which is a body, usually, but not always, present in an organism, and which acts as director of the living processes. Also the ferments in organisms which hurry up chemical reactions (change of starch into sugar, and sugar into alcohol, for example) are proteins. Fundamental then to the formation of protoplasm is the construction of protein-like substances, which must have arisen from amino acids produced by the combination of nitrogen, hydrogen, carbon and oxygen. These elements are present in nature, so that it is conceivable that an amino acid should arise from them, though it is difficult to believe that the amino acid tryptophane would be formed at all easily, and frequently, by chance collision of carbon, hydrogen, nitrogen and oxygen atoms.

It is still more difficult to believe that just the correct proteins to form the basis of the protoplasm of even the simplest speck of animal life came together fortuitously; just as difficult to believe as that, if you take printer's type and shake it together a large number of times, once in your experiments you will get the text of *Hamlet* exactly as Shakespeare wrote it. We must leave the discussion to the materialists and the theologians. It is very diffieult for the average man to believe either the one or the other.

Elementary Organisms

We must start with our living speck of protoplasm. At its simplest it takes one of many forms. There is the amœba, which word means that it "changes its shape." So it does. Resting it may appear as in Fig. 26, but if it "wants" to move, it throws out a false leg, anchors itself by that and drags the rest of the amœba to the new position, the false leg or pseudopod being now

Fig. 28. *Bell animalcule, another minute organism the edge of whose bell is covered with projecting hairs which drag food into its "mouth."*

withdrawn into and merged with the central core. There are plenty of other simple organisms made of a speck of living matter more highly differentiated from each other by their shape. They may be spherical with stiff rods of protoplasm projecting radially from their surface to catch prey like the sun animalcule (see Fig. 27), floating freely in the sea. Alternatively, they may attach themselves by one end to some fixed object, weed or otherwise, and have a bell-shaped enlargement of the other end lined with motile hairs which whip the water towards the inside of the bell—the bell animalcule or vorticella (see Fig. 28). Again, they may invade the tissues or gut of a "higher" animal, such as Man—the malaria parasite, the sleeping sickness parasite (see Fig. 29). A whole book has been written by Clifford Dobell, on the amœbae living in man.

Bacteria, which we have mentioned under plants, are examples, too, of elementary organisms. So many and varied are these simple animals that a whole subject, known as Protistology, has grown up around their study. They have solved the problem of living in various ways and must be considered to have evolved from some less complex "primordial protoplasmic globule" as Pooh-Bah put it.

As we see them there is often a marked differentiation in their parts. There is the fundamental basal protoplasm, called the cytoplasm. Within that there is often a rounded mass, called the nucleus, consisting of a different type of protoplasm, the karyoplasm, with another type of protein in it, nucleoprotein.

This nucleus manages the affairs of the whole, as a managing director manages the affairs of a factory. If you cut it away from the rest of the organism, the rest degenerates. Sometimes the organism has two nuclei, one for vegetative functions and one for reproduction. The bacteria have dispensed with nuclei though they seem to have material of nuclear nature dispersed throughout their cytoplasm.

Some organisms have developed swaying hairs or cilia, which waft them through the water, or create currents in the water which drag in food. Others have an undulating membrane by which they swim. And then within the organism are often vacuoles (minute cavities) which seem to be used for the excretion of water. Around each vacuole is a semipermeable membrane which will let in some things (such as water and salts) and keep others out (see Fig. 30). Also in the cytoplasm are storage materials, which vary with the nature of the animal. Finally, organisms may make delicate skeletons of calcium carbonate or of silica.

One word we have avoided in the above, and that is the word cell, though it appears in its Greek form in cytoplasm. If we look at the

tissues of a complex plant or animal under a microscope, we see that it is divided up into tiny portions, and these, on account of a likeness to honeycomb in the organism first investigated, were called cells.

It is tempting to call the simple animals we have discussed so far "unicellular," meaning that they consist of one cell—and that is the common usage. But it has been pointed out that a bell animalcule is as much an individual as a man or an elephant, and that to classify vorticella as unicellular, and Man as multicellular is like comparing a bee with a swarm of bees. Dobell prefers to call the organisms he studies acellular. But it will be found easier in the long run, if not logical, to think of these protista as unicellular.

Again, we have spoken of higher animals. Somehow or other Man does consider himself higher than an amœba. But the logical person will maintain that an amœba is as

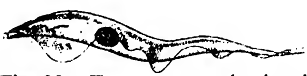


Fig. 29. *Trypanosome, the dreaded parasite which is the cause of sleeping sickness in Man.*

much the product of evolution as Man. It is as advanced in solving the problem of living as Man. Indeed it is immortal and Man is not. The amœba seen today under the microscope had an ancestor very like itself hundreds of millions of years ago whereas Man had not. The amœba when it reproduces divides into two amœbæ, each of which looks just like the parent cell, so each amœba is potentially immortal. All parts except a few tiny cells of Man die. In that respect the amœba has beaten Man. But

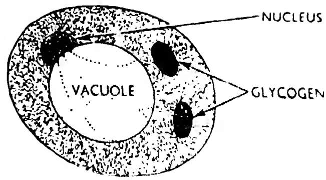


Fig. 30. *Highly magnified section of a yeast cell to show its main characteristics.*

when we look at their powers in controlling environment Man has beaten the amœba, and when the term "higher animal" is used we mean that the animal has acquired a greater power of controlling the environment in which it lives—not that it is more complex or more highly differentiated.

Formation of Colonies

The first step taken in that direction was in forming colonies. We have already seen that in process among plants, *Pandorina* and *Volvox* being lowly examples. There are the slime fungi, too. These aggregate into colonies, lose the cellular divisions between the cells, and advance over decaying matter as an invading army. But at any moment spores may be formed and when these germinate they do not develop into a slime fungus. They form organisms something like *Euglena* without the chloroplast; gyrate through the water; fuse with another; and migrate about like single amœba. Ultimately they meet with other organisms like themselves, fuse together in hundreds and thousands, and make a new slime fungus.

More permanent colonies are seen in the sponges. The sponge of commerce is a skeleton built up by a colony of tiny cells some of which

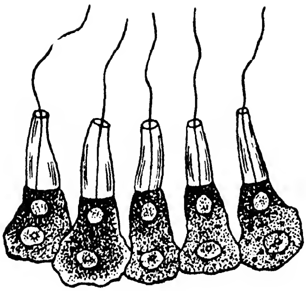
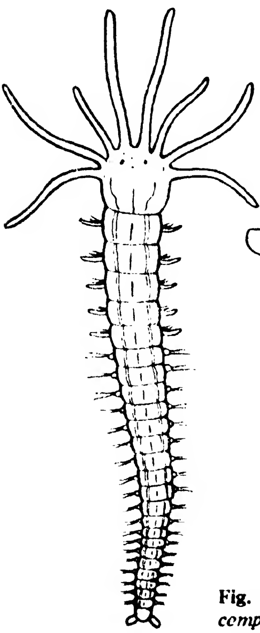


Fig. 31. *Colony of five tiny sponge cells highly magnified in order to show the similarity of each cell to a simple organism of the types illustrated in Figs. 27 and 28. These cells keep the water flowing throughout the "body" of a living sponge.*

(see Fig. 31) are reminiscent of simple unicellular organisms. But here is a colony of cells not all of which look alike or have the same functions.

The cells illustrated are those which sweep the water in through the small openings of the sponge into the interior. There are also cells which act like muscles and control the diameters of the openings; other cells which wander at "will" through the caverns of the sponge; and still more cells, flattened cells, which pave its outer surface. Last, there are cells which manufacture the skeleton. The cells have "learnt" to live together for each other's and their own benefit—but they have been called "undisciplined."

However, aggregation has its value. If the cells of a sponge are forced through gauze so that all its cells are separated one from the other, they will clump together again and build another little



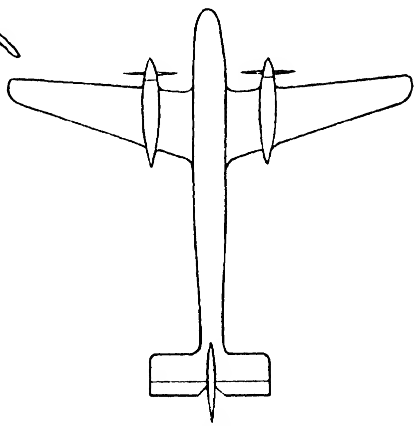


Fig. 32. *Bilateral symmetry of a marine worm compared with that of a streamlined aeroplane.*

sponge. The sponge has a sexual method of reproduction reminiscent of *Volvox*; in both of them we can discern the archetype of reproduction higher up the scale of organisms. The colony has to die and one of its functions is to contain, nourish, and keep alive the immortal sex cells. The sponges get some way in managing environment. They colonize fresh water as well as the sea and exhibit extraordinary diversity of shape and skeleton and contents, but their methods of solving the problem of existence, though they have lasted till today, are "One of life's blind alleys." Thus a new tissue had to be developed to weld together the activities of the cells which compose the colony. This the sponges have not produced, and they live an undisciplined life.

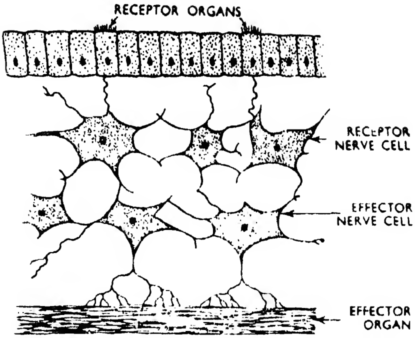


Fig. 33. *Primitive nervous system: enlarged section showing the disposition of the receptor and effector nerve cells. The effector organ in this instance is muscle, which makes vigorous locomotion possible to a colony of cells.*

By the term master tissue a nervous system is indicated. Nerve material is that tissue which lets one part of an animal know what the other parts are doing, or what is being done to them, so that the whole animal can react to the changes in environment. It conducts messages rapidly from one part to another telling each what the rest are doing. It thus welds it into a unity in its actions; just as the various systems of telegraphy, telephony and wireless telegraphy and telephony unite the different parts of, say, the British Commonwealth into a whole which can act as a single reactive element in the world's economy.

Vigorous locomotion is impossible to a colony of cells unless:—

(1) They can detach themselves from their anchorage on rock or weed and become free to explore.

(2) They evolve a bilateral symmetry. By bilateral symmetry we mean that the two sides of an animal are alike in one direction only (see Fig. 32). A pen and a worm are bilaterally symmetrical, a ball and a jelly-fish are radially symmetrical.

(3) They possess a nervous system (see Fig. 33).

Jelly-fish (see Fig. 34) are free swimming and possess a rudimentary nervous system, but have a radial symmetry. Sea anemones can move about the floor of the ocean very slowly and have a still more rudimentary nervous system, but they, too, have no bilateral symmetry. In fact, the nervous tissue and the possession of mouth and digestive system are almost essential developments before bilateral symmetry can be evolved. This is not to say that radial symmetry

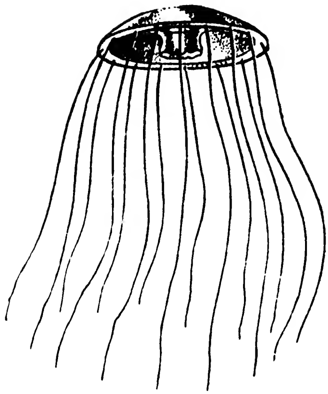


Fig. 34. *Jelly-fish: these organisms have a rudimentary nervous system which causes the bell to undulate rhythmically and co-ordinately.*

is always disadvantageous, for it looks as though the starfish (see Fig. 35) and sea urchins reverted to radial symmetry though they appear to have evolved from animals which have gone quite a long way in the development of head end, brain, blood vessels and bilateral symmetry.

Why should having a localized mouth be of importance? The amœba can form a mouth anywhere around its surface—a most convenient arrangement, it might be thought. The sponges have numerous mouths for intake of water and food. But the *Hydra* (see Fig. 36) has but one. Why should having one mouth instead of many help an animal in the struggle for existence? It is quite likely that it would not unless nervous tissue were present at the same time. The mouth of an animal comes more into contact with environment than the rest of him, and any nervous tissue in that region becomes of predominating value. It tells the rest of the animal what to do. This is illustrated by the fact that nervous tissue is aggregated around the mouth in many animals with the simplest of nervous systems. It is by no means always so.

The jelly-fish has its most highly organized part of the nervous system around the edge of its umbrella. The rest is a nerve net extending over the whole animal. If the annular ring round the edge of the umbrella is cut away, the jelly-fish ceases to pulsate in a regular way to drive it through the water. But each part can still respond to a touch by means of the nerve net which runs through the creature. "A nerve net," as Wells, Huxley and Wells point out," is like a mad telephone system in which there are no exchanges and in which one could call up all the subscribers if one shouts loud enough."

Nerve nets are useful in conducting impulses to all parts of the animal, but the messages carried by them have to be co-ordinated by some more centralized group of nerve cells before an animal can get very far, or have control over

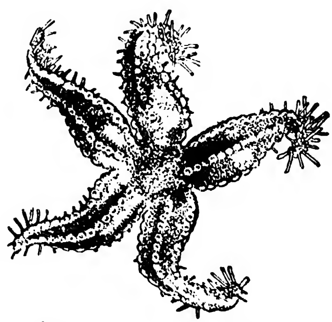


Fig. 35. *Starfish, a typical example of radial symmetry.*

its environment! Having a mouth at one end and a nervous system aggregated around that mouth is useful in the struggle for existence. The development of bilateral symmetry aids, too. The animal becomes more streamlined and can move more easily through the water and even against the stream. If the mouth is at the front end, so much the better. And better still is that the indigestible parts of the food should not have to leave the belly of the animal via the mouth, but via an excretory opening to the rear.

Now the *Hydra* (see Fig. 36), a fresh-water polyp with a rudimentary nerve net and no central control, has simply a hollow inside itself, called a cœlenteron, with only one exit or adit to the exterior, the mouth. Jelly-fish, sea anemones and corals, etc., belong to this class and are called therefore, the cœlenterates—animals with a hollow (cœl-) intestine (entera). The flat worms work on a similar plan, but have the mouth near the middle, although they have developed bilateral symmetry, connective tissue packing, and a nervous system, highly developed in the head end (see Fig. 37). This was definitely a step in the right direction, though it has not carried the flat worms far, possibly because of the lack of development of the alimentary tract—the mouth is not at the head end and has to act as anus as well as mouth—and because the animals remained flat, so as to pick up oxygen and get rid of carbon dioxide to their surroundings easily.

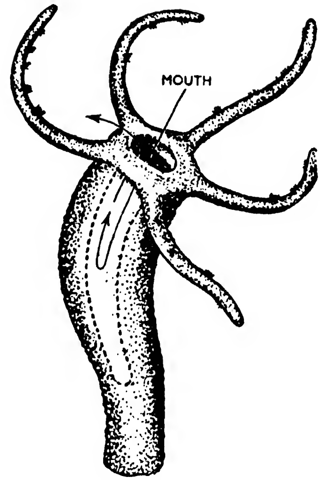


Fig. 36. *Hydra, an animal with a rudimentary nervous system concentrated round its mouth.*

Parasitic Worms

Two groups of the flat worms developed in the direction of becoming parasitic on Man and animals—the tapeworm, alternating between Man and pigs or cattle, and the flukes alternating between sheep on the one hand and snails on the other. Parasitism of this, or any other type, leads nowhere except to gross specialization for parasitism.

The round worms are similarly parasitic, living in the intestine of animals and Man. They have nothing to do except live on what the animal or man has digested, absorb the oxygen it (or he) has absorbed from the air, and reproduce, trusting that the ova produced will find their way, via manure and food, back to the host. Carelessly washed green salad which has been manured with human excreta is a well-known source of infection with worms in China and Italy.

The *Trichinella* of measly pork has a more elaborate history. The fertilized female burrows into the

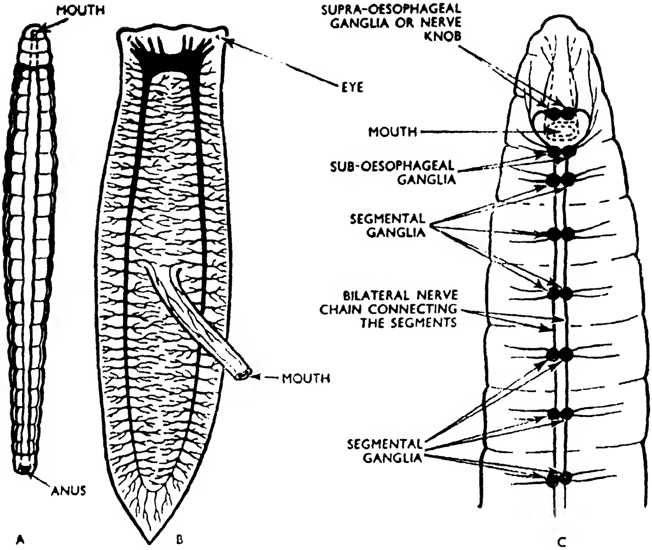


Fig. 37. *Typical annelids:* A—*earth worm, and* B—*flat worm.* C *is an enlarged section of the head end of an earth worm. The nervous systems extend throughout both types, but that at the front end gains dominance.*

tissues of the gut of the host and sets free her young into a part of his circulatory system. They get round to his muscles, where they shut themselves up in a hard casing, hoping to be eaten by another animal and so get back to a gut again.

When Man eats measly pork, not properly cooked, his muscles are invaded by this animal and he suffers from trichiniasis. During the second World War there was a serious outbreak of trichiniasis in the Birmingham region because the pork used for sausage making was imperfectly inspected, and the people of this neighbourhood have an odd habit of eating bits of sausage meat uncooked.

We have mentioned the earth worm and a marine worm belonging to the *Annelids.*

In the earth worm (see Fig. 37) we observe:—

(1) A nervous system running from end to end of the animal, but having its main development in the head end around the mouth;
(2) a digestive system starting at the mouth end and opening by an anus at the rear end;
(3) packing of connective tissue, muscles and tissue spaces (cœlom) between the gut and the outer layers (compare *Hydra*);
(4) a circulatory system to pump blood throughout the body;
(5) segmentation.

It cannot be doubted that all these developments give the earth

worm, or rather, gave some ancestor, a greater control over environment than developments we have studied so far, and that all the higher animals developed from a segmented animal something like the present-day earth worm. By segmentation we mean that an animal is a chain of segments, each of which may and often does, contain a nerve knot on its nerve chain (called a ganglion), a pair of excretory tubules imitating the tubules of the kidney of Man, a pair of reproductive glands, and a pair of appendages to enable it to crawl.

Man, cats, dogs, cattle, reptiles, amphibians, crabs and lobsters are all segmented animals, though it is not obvious, at any rate in us, that this is so at first glance. We must assume, therefore, that our ancestors back in the dark abyss of time were some simple segmented animal typified today by the *Annelids.*

Origin of Segmentation

How did segmentation arise? It is a very tempting theory to suppose that we are here dealing with a longitudinal colony of animals, the front end of which takes on the leadership of the colony and develops special functions, while the other members of the colony follow after, benefiting from the dominance of the front end and specializing for particular functions such as reproduction, excretion and so on.

There are difficulties in the way of such a theory, not the least of which is that any segment should potentially be able to grow into a head or a tail, be able to lead an independent existence, be able to reproduce itself, etc. We know that the different segments of the human body cannot detach themselves from the others and, as Bernard Shaw's charwoman puts it, go to bed and have twins. None the less, we do meet simpler, less organized segmental animals which behave in this extraordinary way. The marine worm of Fig. 37 can grow a "head" half way down its body. After a time the hinder animal rebels, there is a tug-of-war between the two, a split just in front of the head, and then there are two marine worms. Other segmental animals can form a head anywhere in the colony and split up to form new animals. Sometimes the new heads are not developed until the animal splits in two.

If an earth worm be cut in half the front end develops a new tail and the back end a new head. Each segment contains a pair of tubes which act like kidneys and each segment in some forms has reproductive organs. If we imagine a suppression of the separation of these longitudinal colonies into their component parts together with suppression of the power of forming new heads, we should have a segmental animal. The theory is not so fantastic as it seems at first sight, and it is accepted as plausible. Such segmentation would have its advantages: the animal gains size (a Tasmanian earth worm achieves a length of six feet!), it is provided with a multiplicity of parts among which division of labour can arise, and it has "direction" and is streamlined.

In such an animal the nervous system in its front end becomes more important than the rest, and we invariably find that the knots of nervous tissue there are larger, and that they become more and more dominant as we go up the scale of creatures. There is an aggregation of nervous material in the front

end of the animal which takes control and so regulates the activities of the hinder portions so that, though they possess nervous matter which can act independently in a feeble way, they wait on the controlling power of the "brain" end, and are almost helpless without it. This centralizing power in the head ganglia of nerves, is seen at its best in Man. We have already seen this enlargement of nervous tissue in the head end of such a lowly animal as the flat worm (see Fig. 37). This led nowhere in the case of the flat worm because the rest of the animal, though highly specialized, lacks an intestine with two orifices and a blood system. It had to remain flat. In the earth worm, however, we begin to see a dominance in power, shape and size of the headward ganglia, and this is the plan which is followed in later stages of evolution.

Stiffening Material

As animals ascend the scale of evolution and grow larger they may be expected to need stiffening material to protect them from the changes of their environment, packing of the organs of their bodies, and a transport system to carry materials from one part to another. Stiffening material is used in two very different ways. Either it is put on outside—an exoskeleton, or inside—an endoskeleton. In the worms there is little stiffening material, merely a chitinous outer skin, but this has developed in many extraordinary directions in other animals.

The crustaceans—crabs, lobsters and shrimps—put their armour on outside. So do the insects and the spiders who develop the chitinous outer covering into hard material. This has its advantages and disadvantages. Whenever a crustacean grows it has to shed its old suit of armour and retire into a secluded spot to become, for a time, a defenceless creature and a tasty morsel for its enemies (soft-shelled crabs are a luxury food in the United States of America). The molluscs, such as snails and shellfish, developed an organ for the manufacture of an armour made from calcium carbonate and not from chitin. Some, such as the cuttlefish, finding that agility proved of better value than cumbrous armour plate (destroyers with ironclads as a comparison) retain today but a vestige of armour.

An exoskeleton has the disadvantages of impeding expansion—new suits of clothes are an essential—and of cumbrousness. The struggle for existence goes to the agile and the brainy. All animals with an exoskeleton, such as insects, are not necessarily agile. They solve the problem by remaining relatively small, by development of rapidly contracting muscles and by the possession of a good nervous system. In the spiders, the ganglia round the head end of the animal are so overgrown that they compress the head end of the alimentary tract and the animal can take food only in a liquid form by suction.

An endoskeleton possesses many advantages over an exoskeleton. An internal skeleton is particularly useful to an elongated animal. It gives a structure for the muscles to pull upon in the moving of appendages and it can be used to protect the delicate central nervous organization. This was a step taken in the development of vertebrates from some segmental ancestor. First of all a notochord was de-

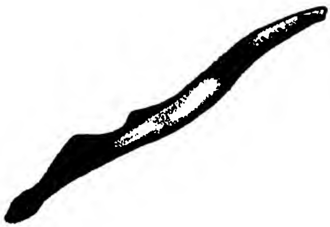


Fig. 38. *Lamprey, descendant of once dominant fish-like creatures, which has a persistent notochord, but a backbone forms round it.*

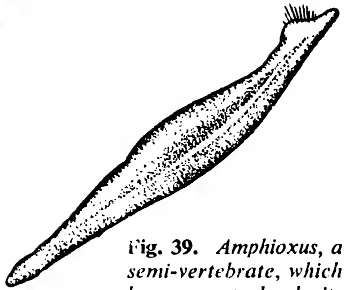


Fig. 39. *Amphioxus, a semi-vertebrate, which has a notochord—its only "backbone."*

veloped. This is a stiff, but elastic rod, lying along the whole length of the body between the alimentary tract and the nervous chain and its ganglia. This notochord forms a mechanical axis from which the muscles of the body have their origin. It is seen at its best and simplest in *Amphioxus* (see Fig. 39), an inconspicuous marine, white, translucent animal about two inches long, found in the sand in shallow waters round Britain's coasts. Some such animal must be the ancestor from which all the vertebrates, including Man, have developed—for in the developing young of all vertebrates a notochord is formed, even though it may later be supplanted by a jointed backbone.

The lamprey (see Fig. 38), a fish still used as food, despite Henry I's trouble with it, possesses both a notochord and a backbone. At one stage of Man's embryonic life he, too, has a notochord, but supplants it with a vertebrate backbone which grows round and protects the precious spinal cord.

The Recapitulation Theory

This theory is of the utmost use to biologists in settling the relationships of animals and plants. The theory states that animals, in their development from a fertilized egg, recapitulate their evolutional history. If Man's embryology shows him at one stage to possess a notochord, then he must have evolved from animals which possessed that organ, even if later he sweeps away the traces of having possessed it. If in embryonic life he has gill slits like a fish then he must have developed from fish-like ancestors.

The theory makes sense of an extremely large number of observations which would otherwise appear senseless, and although we must not push it too far—for example, the gill slits in the neck of a human embryo do not bear gills—it none the less is an extraordinarily good guide for working out the relations of animals and plants. The evidence that vertebrates in embryonic life possess a notochord means that they evolved from some animal ancestor closely related to the *Amphioxus* (see Fig. 39) and the lamprey which have survived till this day.

Here, however, we encounter a difficulty. The nerve chain in the worm and similar animals is below the gut except in its "top" end. There it forms a loop round the

alimentary tract. In vertebrates the nerve chain is above the gut all the way. How did the two change places if they are what they seem to be? One bold assumption is that we vertebrates arose from an invertebrate ancestor which found an advantage in swimming upside down (there are such creatures), and this topsy-turvy existence has remained till this day.

Another theory is that the old alimentary tract, beginning to be swamped by the nervous system, was discarded and formed the ventricles and spinal canal of our nervous system, and that a new alimentary tract *below* the nervous system was developed. This theory, attractive as it may seem to the physiologist with his obsession concerning the importance of the nervous system, has been met with hoots of derision by the zoologists, and is hardly considered by them as worthy of refutation.

However that may be, geological

Fig. 40. *Mud-hopper fish moving a vote of confidence in legs.*

records show us that between 350 and 400 million years ago the first vertebrates had evolved. They were muscular, gilled, tailed like fish, but had a sucking mouth like the modern lamprey. Many were limbless, but there is every gradation from this to well-developed fin-like organs in the position of forelimbs. They had good "brains," and a blood system; and some of them had sharp denticles (protruding teeth) in their skin like the dog fish, but they had no jaws; that was the next invention, and so we reach the true fish.

Originally, all fishes had a skeleton made of gristle and not bone—the shark, the dog fish (rock salmon) and the ray are still like that, having bony structures only in the denticles of the skin and in the mouth. More recently developed fish, such as those we are accustomed to buying from the fishmonger, have true bones, the gristle having been replaced by material containing deposits of lime salts. All the higher vertebrates (amphibians, reptiles, birds, mammals and Man) have true bone, though most of the bone is laid down first in gristle.

Development of Amphibians

By this time, about 350 million years ago, the plants had colonized the land and made it fit for animals to live on, and the animals invaded the land not, probably, to eat the herbage, but to survive from the droughty conditions in the shallow seas and lakes in which they lived. To breathe air they needed lungs, and to walk about on dry or drying land, they needed legs, which were evolved from fins. There are today lung-fish which can live out of water for a time. An example is the tropical mud hopper which gives

Fig. 41. *Duck-billed platypus, a rare egg-laying mammal, found in Australia and Tasmania.*

an idea of how this problem of lungs and legs began to be solved (see Fig. 40).

About 300 million years ago the first amphibians (frogs, toads, newts) dragged themselves out on to land. They were not like modern amphibians, for their backbones were clumsy contrivances and they were protected here and there with armour plate. These primitive amphibians many millions of years ago gave rise not only to modern amphibia but to the first reptiles and so to all the higher vertebrates. However, they were not wholly emancipated from water. The amphibian spends its larval life in water and has so little conquered land that it cannot bear drought.

Reptiles and Birds

The next step was in the direction of reptiles—the modern representatives of which are lizards, tortoises, crocodiles and snakes. These invented the shell egg, a drought-resisting fragment of life, comparable to the drought-resisting seed of plants developed much about the same time. The age of reptiles definitely began some 180 million years ago.

There were still conquests to make: (1) subservience to the temperature of surroundings, and (2) travel in the air. The birds evolved from reptiles to do both. They keep their temperature constant, i.e. are warm blooded, and they can fly. The birds appeared some 120 million years ago and there are "missing" links, indicating the steps evolution took. Keeping one's internal temperature constant means that one can live in temperate and cold regions as well as warm. The reptiles, even those approaching warm bloodedness such as the crocodiles, can do their best only in the tropics. So the birds and the mammals (ourselves, monkeys, dogs, cats, bats) by regulating their temperature, beat the reptiles. The only mammal to conquer the air, till man invented the flying machine, was the bat.

Development of Mammals

There were, however, still problems to solve, for example, this egg business. Eggs could be cast out on the world by the million, as most fish do, or they could be given shells and a considerable amount of food within, and then left for the sun to hatch. They could be hatched and the young fed, till fledged, by the parents, or the egg could be hatched inside the body of the female—as some snakes do. Again the eggs could be hatched thus and the immature young, when born, could be fed from special milk-producing glands, mammæ, on the body of the female.

That is the line of development taken to produce us.

First of all there was the "non-placental" mammal originating

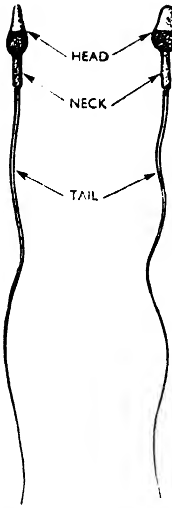


Fig. 42. *Human spermatozoon, highly magnified: (left) in profile and (right) surface.*

earlier than the birds. The placenta (see Fig. 44) is an organ developed by the young embryo to absorb nutriment from the uterus (womb) of the mother. One type of non-placental mammal lay eggs, hatches them and feeds its young on milk—the duck-billed platypus is an example (see Fig. 41). The other develops the egg within the body of the female, gives birth to the offspring in very immature form, and carries it in a pouch where the mammary glands are placed—examples of this type are the kangaroo and the opossum. Finally, there are the placental mammals, to which most of the familiar animals belong—cat, rat, dog, deer, cow, elephant, monkey and Man. Of these, Man has the greatest amount of control over his environment and is for that reason accounted the highest mammal.

Development of Man

Man won his position by his highly developed brain, by his erect posture which freed his fore-limbs to develop into hands, by the opposition of thumb to forefinger which gave him the chance of making tools, by relegation of sense of smell into the background and by development of sight and hearing, and by his stereoscopic and colour vision.

Man differs anatomically from the ape in his brain and his calf and buttock muscles, and he has inherited the earth for about 10 million years only. The rest of this chapter is devoted mainly to him.

Sexual Reproduction

All life reproduces itself, sometimes by dividing into two (asexual reproduction, see page 113) and sometimes by the union of two cells set apart for the purpose which then grow into a new individual. Usually, though not always (see *Chlamydomonas*, page 115), the cells are differentiated. There is a motile cell (the male cell or sperm) and a sessile cell (the female cell or ovum). They may arise on the same organism as in most flowering plants, oysters, worms, or on different organisms (some plants and vertebrates) and the terms male and female are applied to those organisms. Both sperm cells and ova may be scattered broadcast into environment, a most wasteful method, or the ovum may be retained in the female organism and elaborate means be evolved for introducing the sperm cells into the neighbourhood of the ova. This is the case in Man.

The sperm cells are produced in the testis of the male. When ripe they leave the testis and are stored for a time in the yards-long coiled epididymis. The female cells are matured in the ovary, and once a month one (or sometimes two) are discharged from the ovary (ovulation), pass out into the abdominal cavity, are seized by the fallopian

tubes and pass down into the uterus.

Sexual intercourse brings the sperm cells to the mouth of the uterus. In the sex act the penis of the male is inserted into the vagina of the female. When the sex act is completed the sperm cells have been projected near the mouth of the uterus (see Fig. 44) and make their way, some hundred millions of them, under their own steam through the uterus and up the fallopian tubes. Human sperm is very motile. It consists of a tiny head, a neck, and a long tail. This tail by lashing to and fro drives the sperm along on its way (see Fig. 42).

The sperm cells probably meet the ovum (see Fig. 43) on its way down to the uterus and one, out of the hundred or so millions, fuses with it and fertilizes it. Sometimes a married couple cannot beget children, and where this can be proved by medical examination to be due to the male partner, and both partners are willing, sperm may be donated by another male and introduced artificially into the vagina of the female with success.

In animals this artificial insemination was achieved a hundred years or more ago and is now used in agriculture in the case of pedigree animals who can thus sire many more offspring than by normal means. With human beings it is practised in the United States of America and to a much more limited degree in Great Britain.

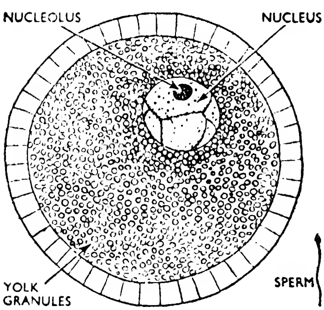


Fig. 43. *Human ovum in section, compared with human sperm. Both have been drawn to the same scale.*

Growth of Embryo

The fertilized ovum passes down the fallopian tubes, meanwhile beginning to divide and divide and by the time it reaches the uterus has formed a mulberry-like group of cells. This burrows its way into the tissues of the uterus between the openings of the fallopian tubes and begins to absorb growth material from the walls of the uterus. This "fixation" is a time when there often is a transient upset in the health of the mother. If the ovum does not fixate, it degenerates and is passed out to the exterior at the next period. It would take too long to describe how this mulberry-shaped mass of cells develops into a baby. It must suffice to say that it grows a placenta (see Fig. 44) to absorb nourishment from the mother's blood; it passes through a fish-like stage at about the third week; by the fourth week it develops eyes, and buds from which the arms and legs arise (see Fig. 44).

It still has a tail. By the second month it is recognizably human; it has fingers and toes and the tail is hardly noticeable. After that, through the next seven months, it grows and grows from an embryo barely an inch long into a full term child. At the end of the ninth calendar month (say 270 to 285 days—sometimes more—from the last period) the baby is ready and waiting to be born. If a baby is

born before this time it is termed premature.

The greatly enlarged muscles of the uterus begin to contract at intervals which grow shorter and shorter. This dilates the mouth of the uterus. Then more and more powerful contractions take place accompanied by contractions of the muscles of the abdominal walls. The membranes enclosing the baby, with their fluid contents, are pushed down through the mouth of the uterus and the baby follows normally head first. Slowly the head of the baby is thrust out of the uterus and through the vagina to the outside world, the arms, trunk and legs following. The baby is born.

The baby is still attached by its umbilical cord to the placenta, which later detaches itself from the walls of the uterus and in its turn it is born (the afterbirth). When the doctor or midwife decides that the remaining blood of the placenta has been squeezed by uterine con-

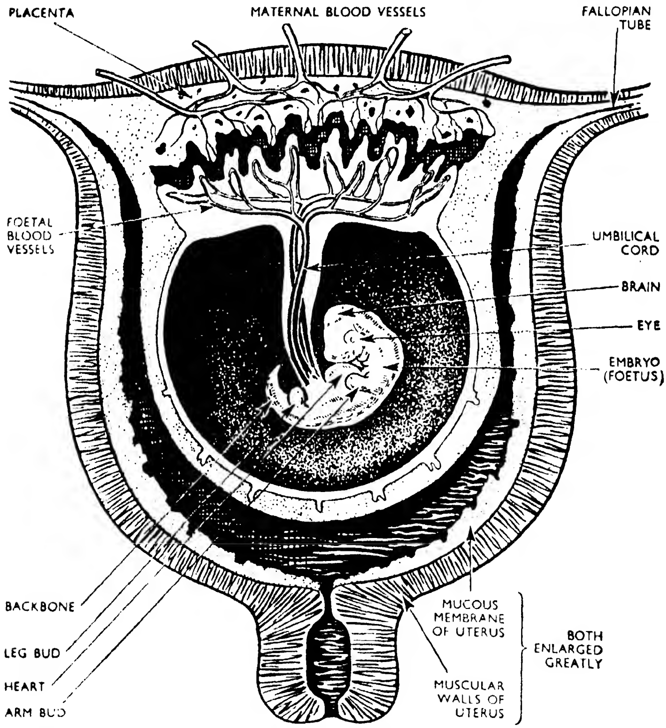


Fig. 44. *Diagram showing the normal disposition of an embryo at the third or fourth week. Note the umbilical cord which is the "food" pipeline.*

tractions into the baby, via the umbilical cord, this cord is tied in two places—one some inches away from the baby and the other some inches away from the mother. The cord is then cut with a sterilized instrument and the baby is ready to live a life in the external world.

For the baby's nourishment the breasts of the mother have developed to secrete milk, at first a modified milk called colostrum, but after a few days true milk. This the baby obtains by sucking, and its life for some weeks consists of little more than long intervals of sleep punctuated by sucking and crying. During the first week the baby usually loses a few ounces in weight. Afterwards, the baby begins to grow fairly rapidly and put on weight (4 to 8 oz. per week).

By the end of four months the child should have doubled its birth weight and by the end of the year trebled it, thus growing faster than at any later age. The age of weaning from milk varies greatly according to fashion. As healthy children begin to cut teeth at seven months it is reasonable to suppose that they may be introduced to solid food at that age. American pediatricians (child specialists) use mashed ripe bananas as early as at three months and in Great Britain six months is the rule. From one month onwards it is customary to augment the feed with vitamin C, which is found particularly in orange, tomato, rose hip or blackcurrant juice. At six months it is possible to give children a source of iron, sieved greens (not spinach), mashed cooked yolk of egg or minced cooked liver. At nine months it is usual to wean the child completely from breast milk or milk fed from a bottle. From nine months to three years the child is gradually taught to take a normal adult diet, except that indigestible foods, such as fried foods, pastry, pickles and coarse vegetables, are best omitted. It has been proved that children do best on a diet based mainly on cow's milk, eggs, meat, fish, vegetables and fruit, omitting from the menu highly refined foods such as white bread, sugar and, naturally, tea, coffee, cocoa or chocolate. This is equivalent to saying foods in which the vitamin and mineral elements are at their greatest amount.

Growth rate slows till puberty is reached (thirteen in a girl and fourteen in a boy) when it accelerates markedly, to slow down again at seventeen or eighteen. It is usually completed by twenty-one, though there are exceptions. The average weight of a British boy at puberty is 7½ stones, while a girl weighs about one stone less. These weights are much the same as for American boys and girls, and there is no reason why all children should not attain this standard in a civilized community. Growth is partly due to heredity and partly due to food. There is no doubt that children of the poor in Great Britain lack height and weight through bad food and going to work too early. At puberty, i.e. when hair grows under the armpits and around the sex organs, the boy or girl is capable of reproduction, though not physically full grown. It is certainly advantageous to postpone sex activity till physical maturity.

The Skeleton

The human body is supported on an internal skeleton of bones. These serve to stiffen the body and to provide levers upon which

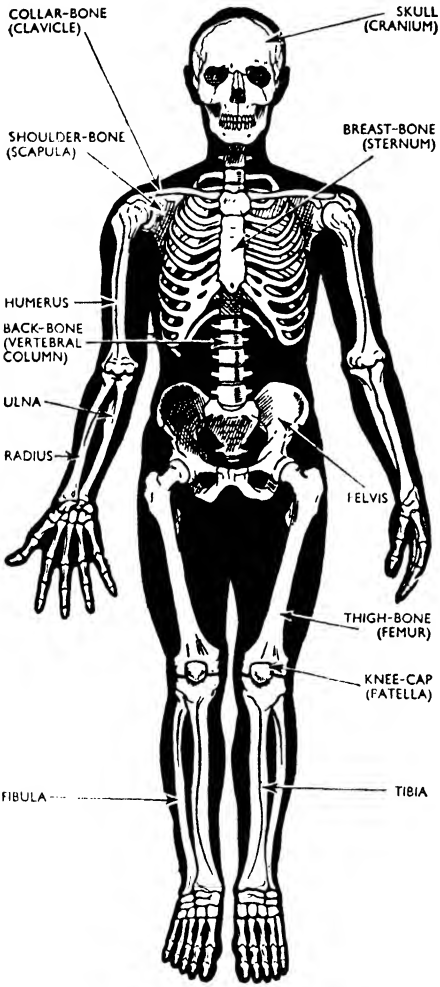


Fig. 45. *Human skeleton (front view) showing the framework of bone on which the body is moulded. In addition to giving shape and firmness to the body, the skeleton affords attachment for the muscles and it protects vital organs, such as the brain, the spinal cord, the heart, and the lungs.*

the muscles of the body work. The important groups of bones (see Fig. 45) are: (1) skull and jaw; (2) vertebral column or backbone; (3) brachial girdle to which the arm bones are attached; (4) pelvic girdle to which the leg bones are attached; (5) the bones of the arms and the legs. These bones are kept in position: (*a*) by being dovetailed into one another, such as the bones of the skull; (*b*) by being tied to one another by ligaments, such as the thigh-bone to the pelvic girdle; or (*c*) by ligaments attached to muscles, such as the thigh-bone, the knee-cap and the bones of the lower leg.

Bones are formed by the deposition of calcium and magnesium salts, mainly the phosphate, carbonate and fluoride in connective tissue. The original scaffolding is gristle in most of the bones of the body, but as the body grows this scaffolding is swept away and replaced by true bone. The replacement starts some two and a half months before birth, but is not complete till the child has finished growing. Faulty deposition of the calcium salts in the manufacture of bones is seen in rickets, which usually occurs, if it

occurs at all, between the ages of six and eighteen months.

Rickets may, however, occur at all ages from before birth till adult life. The correct building of bone depends upon: (*a*) one of the vitamins (see below), and (*b*) a good supply of calcium and phosphorus in the diet throughout life.

Bone is continually being remodelled throughout life and this depends upon the presence of vitamins A, C and D in the food.

Muscle

The muscles of the body are attached to the bones and alter their disposition in space. They may hold the body stiff, or bend or straighten the joints, fix the joints in particular positions, draw the limbs towards the mid-line or away from it. Sometimes the muscles are arranged in a ring around a hollow organ and so can close an orifice, or relax to allow that orifice to open. Such sphincter or strangling muscles are seen in the iris of the eye and around the exits of bladder and intestines.

The muscles we move at will are called the voluntary muscles, and these are built on a particular plan of highly specialized cells. The smallest units are long parallel-sided fibres having a cross-striping of light and dark bands. They are united into bundles by fibrous connective tissue. In a large muscle there may be any number of these tiny fibres up to 300,000. The function of muscle is to contract; that is. shorten with an accompanying swelling of the belly of the muscle (see Fig. 46).

The voluntary muscles contract swiftly and are directly under the control of the nervous system—they are paralysed when cut off from that system.

In addition to the voluntary muscles there are the involuntary muscles (muscles which we cannot work at will) which form the walls of the heart, the blood vessels, the alimentary tract, bladder and uterus, the sphincter muscles of the iris of the eye. When our hair stands on end due to cold or fright, muscles are pulling on the hairs of the skin and erecting them. Involuntary muscles are made of much shorter and more spindle-shaped fibres than the voluntary muscles. They contract slowly and can continue to act without the control of the nervous system. The involuntary muscles of the heart communicate with each other by branches; they are cross striped like the voluntary muscles.

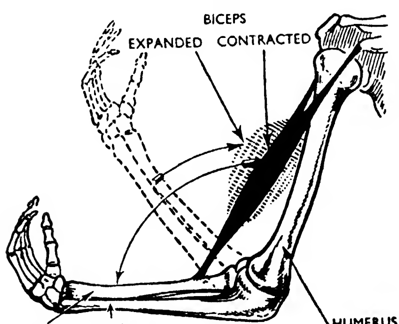


Fig. 46. *Voluntary muscle diagram showing how movements of the fore-arm are produced by the contraction or relaxation of muscles.*

Source of Muscle Power

The source of power of the muscles is the combustion of a sugar known as glucose or grape sugar. To supply the muscles the

blood carries sugar to them in small but constant amounts. About one-tenth of 1 per cent of blood is glucose and if this amount falls much below 0·08 per cent the individual suffers great fatigue. The quickest pick-me-up in such a state is glucose or, if that is not available, cane sugar.

The combustion of this sugar is not, however, a simple burning such as is seen when a lump of sugar is thrown into the fire, but consists in a train of reactions in which phosphoric acid, several ferments and at least two vitamins take part.

Skin and Hair

Covering the body is a semi-waterproof material, flexible, elastic, greasy and beset with hairs, blood vessels and sensory apparatus—this is called the skin. Its thickness varies with location, being greatest on the soles of the feet (for obvious reasons) and thinnest in the abdominal region. The hairs are for protection and the shedding of unwanted water; they act as thatch. Also they aid in temperature control in furry animals. Around the bases of the hairs are nets of sensory nerves—probably that is the reason why Man has retained hairs which are useless in him for temperature control. Grease-producing glands open into the sockets of the hairs to make the skin waterproof. Also sweat glands pour sweat on to the surface of the skin for temperature control. Finally, the skin's blood vessels, apart from their function in bringing material for renewal of skin and hair and for feeding the glands of the skin, are of importance in keeping the body temperature constant. On a hot day they open and allow heat to be lost from the body; on a cool day they contract and conserve the heat of the body.

The internal linings of the organs of the body are much thinner and simpler. They have fewer layers and, except in the mouth and gullet, ureter, bladder, and urethra, each layer is reduced to the thickness of one cell. The cells may be flat and arranged edge to edge, like paving stones, as in the blood vessels, or columnar and standing side by side like sticks in a bundle of wood. The columnar cells lining the air passages also have cilia on their surface. These are moving hair-like appendages which are in constant motion sweeping mucus and entangled dirt up towards the exits in larynx and nose. All such lining tissue is called epithelial tissue.

The Circulatory System

Throughout life there is a continuous circulation of nutrient material to all parts of the body and to its innermost recesses by the blood stream. The same system carries away waste products. If the circulation of the blood ceases even for a few seconds the person faints; if for longer he dies. The blood is maintained in circulation by the heart (see Fig. 47), a four-chambered organ the left side of which squirts blood into the arteries of the body while the right side sends it to the lungs. The arteries break up into smaller and smaller vessels and ultimately they pour their contained fluid into hair-like vessels called capillaries (see Fig. 47). These form a network in all the organs of the body, then reunite and pour the blood into the veins whence it is returned to the heart. Those from the lungs go to the left-hand side of the heart and those from the rest of the body into the right-hand side

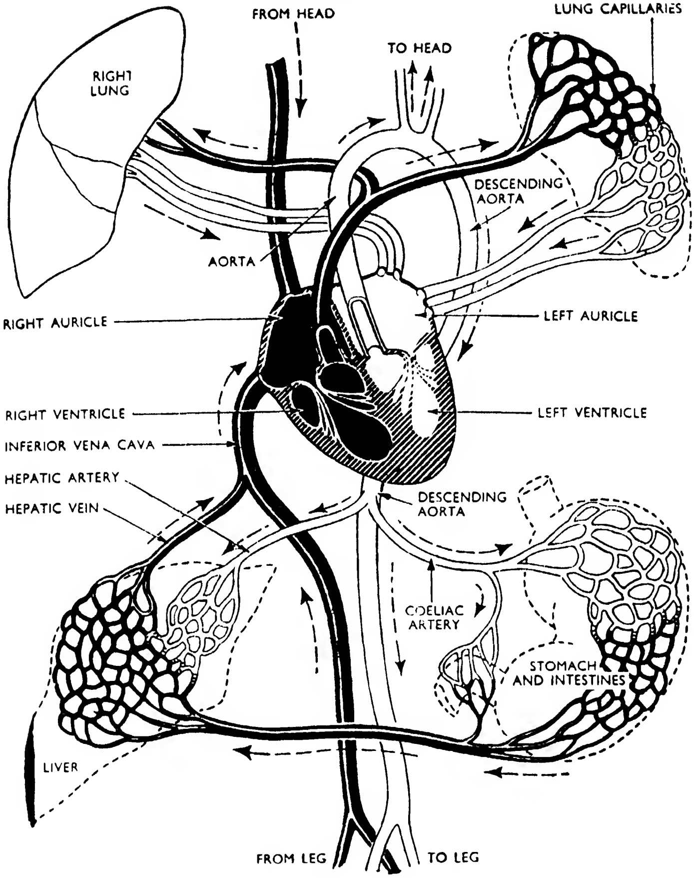


Fig. 47. *Schematic diagram showing the circulation of blood throughout the human body. The heart pumps blood into the arteries which carry it to specific capillaries, etc. The blood continues to flow through these capillaries into veins, whence it is returned to the heart.*

of the heart. Finally the blood is back in the place in which it started and the process goes on again and again till we die (see Fig. 47).

Blood is a sticky fluid containing blood cells of two types, red and white. The red blood corpuscles are that colour because of a pigment, hæmoglobin, whose function is to carry oxygen from the air in the lungs to the tissues. The white blood corpuscles, much fewer in number, have the function of poisoning certain microbes, making

them more edible, and eating them. The stickiness of blood is due to three proteins, one of which makes the blood clot in the presence of a ferment. In the absence of the ferment a person bleeds to death even from a small cut. This trouble is called hæmophilia and the person a "bleeder." Vitamin K is essential to the making of the ferment but does not cure bleeders. If the percentage of the proteins runs much below 6 per cent (say 3 per cent) the person gets dropsy—waterlogged tissues or hunger œdema, as seen in Holland, Greece, Poland and other countries which were under German occupation in the second World War. It is due to a low protein diet and can be relieved by good protein feeding.

There are at least five types of human blood, one quite rare, and the distribution of these types varies but little in Western Europe. This upsets the myth of German blood being racially pure. But as one goes across Europe and Asia the distribution of the different types does change somewhat. One of these types is compatible with all other types and may be injected into the veins of anyone without disaster. Another type is compatible only with the blood of its own type, and so on. That is why each voluntary donor of blood has to have his blood classified, as was done on a large scale during the second World War. The blood of a recipient also has to be classified.

Blood never actually gets into the tissues of the body except in disease (scurvy) or after an accident. A bruise is caused by blood being let out of blood vessels under the skin, and its rainbow hues are caused by the changes produced in the red blood pigment as the body makes away with it. The middleman between blood and tissues is the tissue fluid which seeps out of the blood vessels and carries protein, dissolved oxygen, amino acids, salts and sugar from the blood to the muscle cells, liver and brain cells and so on.

To keep this tissue fluid moving it is drained by the lymphatic vessels, which are like blood capillaries except that they contain lymph and not blood. These drain into larger and larger lymph vessels which ultimately empty into two large veins near the heart. There is thus a circulation of lymph as well as circulation of blood, but it is sluggish compared with blood circulation. Perhaps two quarts a day of lymph pour back into the blood stream compared with the three quarts of blood per minute which pour into the right chamber of the heart, even when the body is at rest. None the less the lymph must not be impeded. Such a stoppage of lymph flow under the skin is held to result in chilblains.

The Respiratory System

The respiratory system is an apparatus to get oxygen into the blood and carbon dioxide out of it. The system consists of the two lungs, which are elastic bags in the chest cavity, and the passages leading to the lungs—nose, wind-pipe, bronchi, bronchioles (where we "catch" bronchitis). In the walls of the minute sacs forming the lungs there are an enormous number of blood capillaries. There is the thinnest of membranes between the air in the lungs and the blood in the capillaries, so oxygen can easily pass in and be absorbed by the red pigment of the red blood corpuscles, and carbon dioxide,

carried in solution in the blood, can pass out. The air in the lungs is changed in composition every time we raise the chest wall or lower the diaphragm, a muscular sheet separating the chest cavity from the abdominal cavity (see Fig. 48). Fresh air is dragged into the lungs when the chest wall is raised and the diaphragm flattens. When the chest wall falls and the diaphragm resumes its dome-like shape, some air—air in which there is now more carbon dioxide—is squeezed out. Thus at each inspiration we take oxygen from the outside air and at each expiration we give out some carbon dioxide, always in volume somewhat less than the oxygen absorbed.

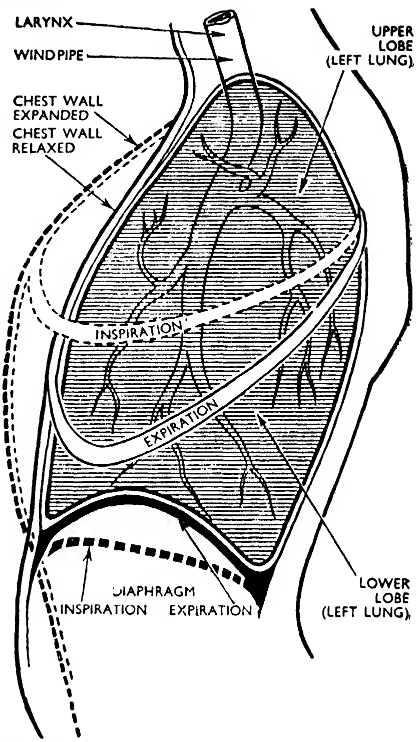


Fig. 48. *Diagram showing position of ribs and diaphragm in expiration and inspiration.*

The rate and depth of respiration varies with what we are doing. At rest we absorb about four-fifths of a pint of oxygen per minute and give out a little over three-fifths of a pint of carbon dioxide. If we take exercise, both increase, and the carbon dioxide output rises to about the same as the oxygen intake. This is because we burn sugar during exercise, and the oxygen needed to burn sugar has the same volume as the carbon dioxide which burning sugar produces.

Carbon dioxide is a waste product of the body and is got rid of most conveniently by the lungs because it is a gas. But other waste products of the body, phosphates, sulphates, urea and uric acid, waste products from protein, are solids and have to leave the body in solution. This is managed in the urine. For this kidneys have been evolved.

The Urinary System

There is a large blood supply to an extraordinarily complicated mass of tubules which are found in the kidney. Fluid is filtered off from the blood at the near end of the tubules; as this fluid passes down the tubules it is probably condensed by water passing back into the capillaries so that the unwanted substances are

left behind. The fluid so condensed and altered in composition is known as urine, and it passes out at the distant end of the tubules into collecting ducts, which carry it on to the ureters (see Fig. 49). Thence it passes unchanged to the bladder where it is stored until it is convenient to get rid of it.

The composition of urine tells us much about the amount of protein the body is using, and its origin. If the body is using protein from food there is much urea in the urine; if it is using up its own protein the proportion of urea falls and the uric acid and creatinine (another product of protein changes in the body) increases relatively to the urea substance.

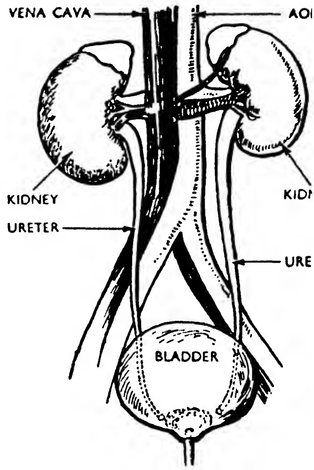


Fig. 49. *Urinary system showing the journey of waste products from the kidneys to the bladder.*

The Digestive System

One of the most interesting parts of Man's internal apparatus is the digestive system. Food, as we eat it, is of little use to the cells of the body till its nature has been drastically changed. It contains eight important ingredients: proteins, fats, carbohydrates, mineral elements, vitamins, extractives, roughage and water.

Proteins have been mentioned as forming the basal substance of all living organisms.

Fats most people recognize.

Carbohydrates are such things as starch and the various sugars, of which two have been mentioned: cane sugar and glucose. They get the name carbohydrate because they are made from carbon and hydrogen and oxygen, and the last two are in the same proportion as in water (*hudor* is the Greek for water). Water has two atoms of hydrogen to one of oxygen (H_2O). Glucose has twelve atoms of hydrogen to six of oxygen—again two to one. Cane sugar has twenty-two atoms of hydrogen to eleven of oxygen, i.e. two to one. Starch, very much more complicated than these sugars, has the same ratio of hydrogen to oxygen.

Mineral elements are substances like calcium (from chalk), iodine (from sea water), iron (from green plants, liver and rusty cooking implements), and sulphur (mainly from proteins). These mineral elements are essential to life, and the dietician lays great store by foods containing calcium (milk, cheese, watercress), iron (see above), and iodine (fish).

Vitamins. These are substances found in small to minute amounts in foods. There are about a dozen of them, all essential to man (best sources are dairy products, green vegetables, summer and citrus fruits, fat fish, liver and meat).

Extractives are flavourings which

can be extracted (hence the name) by water or alcohol. They make food interesting and palatable, but have little food value. A good example is meat extract.

Roughage is a term applied to the indigestible parts of foods, e.g. the woody fibres of plants. They stimulate the stomach and intestine to get a move on.

Water is found in all foods in varying amounts (90 per cent in a cabbage to 10 per cent in a dry biscuit). It is completely essential in diet and more beyond what is found in foods is invariably taken.

As all tissues are formed from proteins and because they suffer wear and tear, proteins are essential in diet. But the body cannot make use of foreign proteins (in the form in which they are eaten) to patch up human tissues—indeed, such proteins are poisonous. The body does need, however, the amino acids from which such proteins are built up, so it has to tear proteins to pieces, i.e. into their constituent amino acids, so that it may pick and choose from these and build human protein.

Fats are insoluble in water so they must be rendered soluble or at least so finely divided into droplets that the body can use them.

Starch, again, is utterly useless as such. It is insoluble in water and, even if rendered soluble by cooking, will not pass through the linings of gut and blood vessels. It has to be turned to glucose before the body can use it. Similarly cane sugar, milk sugar and malt sugar cannot be used by the body till they are changed to glucose (grape sugar), fructose (fruit sugar) and galactose.

Many mineral elements, such as calcium, iodine and iron, can be absorbed as salts soluble in water and do not need digestion. Sulphur is absorbed as two amino acids, and the vitamins mainly in an unchanged state.

Many foodstuffs, then, have to be torn to pieces, physically (by chewing) and chemically before they are of any use to the body, and to do this and absorb the products, the body has an alimentary tract within it, some twenty-two feet long in the dead subject but only nine in the living. Into this tract numerous glands secrete, producing slippery material (mucin) and ferments; the latter bring about the chemical changes needed.

Cooked starch is partially digested in the mouth and is fully digested in the small intestine. Proteins are started on their way to amino acids in the stomach and finish it in the small intestine. Fats must wait till they get to the small intestine and so must cane, malt and milk sugars. The end products are *all* absorbed into the blood in the small intestine.

Large Intestine

What then is the use of the large intestine? It was fashionable at the beginning of the twentieth century to consider this organ a positive death trap. Microbes flourish there and manufacture malodorous and poisonous materials which, if they were to get into the blood, would cause ill health. Hence the cry for purgative foods and medicines and operations to remove the large intestine. Probably all this is nonsense. If the large intestine is a death trap it is amazing that evolution has tolerated it for 10 million years in Man! Moreover, recent research has shown that it has its advantages. It absorbs some water and it acts as a reservoir. If it did not absorb water man would suffer

from diarrhœa all the time. It incubates microbes which make many or all of the vitamins of the B complex as they are called, and these are absorbed there. So purgation and operation upset the chance of a good source of vitamins B; so, too, do the new drugs of which M. and B. 693 is an example. Modern medical opinion is more and more convinced that one should not monkey with the large intestine!

How much food do we require per day? It is not possible as yet to give a precise answer to this question. We need food for energy, which we get mainly from starches, sugars and fats; for amino acids, which we get from the proteins; and for mineral elements and vitamins which we get mainly from dairy foods, vegetables and fruits and fat fish. The soundest advice for the layman is: Take a pint of milk, one ounce of cheese and an egg per day, herrings or other fat fish twice a week, green vegetables and fruit every day, and for the rest live as most people in Great Britain do. Four or five meals a day are best and so long as a healthy life is led, with real moderation in late hours, stuffy surroundings, tobacco and alcohol, appetite is the best guide to the needs of the body.

This does not mean that no estimates of the needs of the average person can be made. No country, for instance, can wage war satisfactorily which cannot guarantee three thousand calories of food energy per day to its non-combatants and four thousand to its fighting forces. This means that the food eaten per day, if burnt as fuel in the body, would give out enough heat to warm thirty litres (fifty-three pints) of water all the way from ice cold to boiling point for the civilian, and forty litres (seventy pints) for the soldier. It is also agreed that, on the average, a person should take two and a half to three ounces of protein per day of which at least one-third should be protein from animal sources (milk, eggs, cheese, fish and meat), which is roughly represented by either a quart of milk, or five to six eggs, or four and a half ounces of cheese, or eight ounces of fish or meat. Individual needs vary so much that no actual figures can be given for any one person. So long as the diet is based as above and appetite is the guide, mistakes in diet cannot easily be made.

The Nervous System

So far we have dealt with special systems in the body, e.g. the digestive system, the respiratory system. Each of these may be made up of, say, 50,000 million cells. Even a muscle such as the biceps muscle of the upper arm may have 300,000 cells in it. Yet all these cells work together. Moreover, all the muscle fibres in the whole of the body work together. It is probable that if a man, standing at attention, raises his arm in salute, the pull in every single muscle of his body is altered.

Supposing he merely raises one arm to the horizontal. It is clear that the pull on every muscle in that arm is altered. The movement also alters the position of his centre of gravity. That entails his pushing harder with one leg than the other on the ground. Therefore each muscle in each leg must have its tension altered. The same is true of the trunk and neck. Possibly the tensions in the muscles of the arm not raised, and in the tongue, jaw and eye, are unchanged, but they are a small part of the whole. But

how are all these muscle pulls co-ordinated? The answer to that question is the nervous system and the key word in the study of that system is integration.

The dictionary meaning of integrate is to combine parts into a whole, and that is what the nervous system does. Each cell in the body can lead an independent life. Cells taken by Alexis Carrel from an incubating chicken's heart in the second decade of this century are still beating, or rather their direct descendants are. But when a cell is *in* the body its activities have to be integrated with the activities of all the other cells to produce a unity of action. Cancers are groups of cells which do not submit to integration. They have run amok.

There are various modes of integration of the cells of the body. Anatomically they are integrated by skin, tendons and a skeleton, much as the contents of a parcel are integrated by putting brown paper and string around them. Then the blood and lymph systems also integrate the activities of different parts of the body (see later), much as the postal system integrates the activities of the taxpayer with the needs of the exchequer. But the most rapid mode of integrating an organism into a whole is by the nervous system.

As the struggle for existence went to the swift and the agile, the better the nervous system, the better the chance for survival. Needless to say, Man's dominance over all other animals is based on his supremely competent nervous system. An analogy may help. Before the advent of railways and steamships the British Empire and its armies were so badly integrated that a battle was fought between British troops and those of the United States at Fort Jackson, just outside New Orleans, after the peace treaty between the two nations had been signed. Today the British Commonwealth is so integrated that the whole assembly can be, as it were, at the bedside of a dying monarch.

The central part of the nervous system is, as we have said, enclosed within bone (skull and vertebræ). It consists of (*a*) some 2,000 million cells (as many as there are inhabitants on the earth), (*b*) the fibres which connect these with other cells and (*c*) the connective tissue which supports and ties the cells and fibres in position. Wherever the connecting fibres are dominant we have "white matter" and where cells predominate there is "grey matter."

In the spinal cord grey matter is inside the white (Fig. 53), but in two important parts of the brain the grey matter has got outside the white (Fig. 50). This is considered to be an enormous advantage. It gives the grey matter a chance to develop, expand and ramify, unhampered by enveloping white matter. The brain of Man has developed particularly in this direction.

There has been throughout evolution an ever greater concentration of the nervous system towards the upper end of the body and this is especially marked in Man. Man's brain is out of all proportion to those of other animals, whereas his spinal cord is not so very different. His spinal cord is clearly segmented, yet even so its segments are nearer the brain than the corresponding vertebræ of other animals. Especially is that so with the lower vertebræ. It is as though the segments were dragged upwards to be nearer

the brain. Queerly enough some sensory cells have remained outside the central nervous system (Fig. 52), as have motor cells governing the movements of involuntary muscles and secretion of glands. These, however, are exceptions to the centralizing tendency.

Central Nervous System

The parts of the central nervous system are as follows:—

(1) *Spinal cord.* Mainly concerned with movements of arms, trunk and legs.

(2) *Medulla oblongata.* Government of salivation, stomach secretion and movements, intestinal secretion and movements, heart and blood vessel control. Movements of tongue and larynx.

(3) *Pontine region and cerebellum.* Guidance of movement, movements of jaws. Outward and lateral movement of the eyes.

(4) *Mid-brain.* Movement of eyes.

(5) *Basal ganglia.* (*a*) Thalamus (Fig. 50). Chief relay station for all sensory impulses. (*b*) Corpora striata. Chief motor centre for lower animals and in man a centre for guiding and controlling willed movements.

(6) *Cerebral hemispheres* (Fig. 50) to which all sensory impulses, *except those of pain*, are relayed; from which voluntary motor impulses arise; in which recognition of the "meaning" of sensory impulses is made and with which we *think*. Knock out: (*a*) the visual areas at the back, to which fibres from the eyes run, and the person becomes blind (Fig. 51); (*b*) one side only and he is blind in one half of each eye; (*c*) the part just outside the visual area, but not the visual area, and

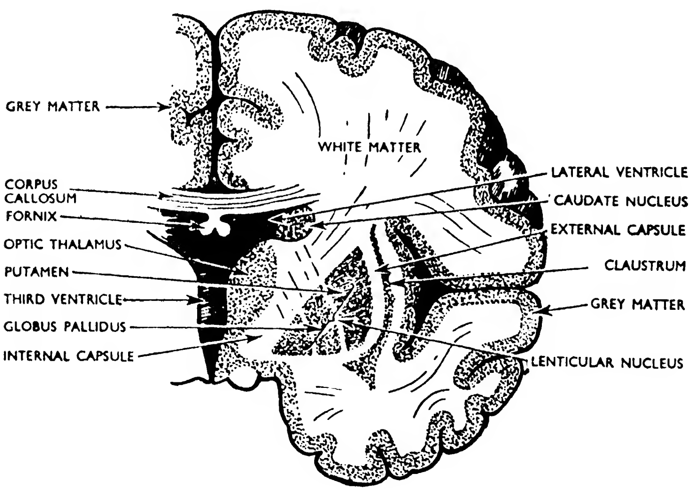


Fig. 50. *Section of the upper brain to show the distribution of grey matter. Note the older parts which are still enclosed in white matter.*

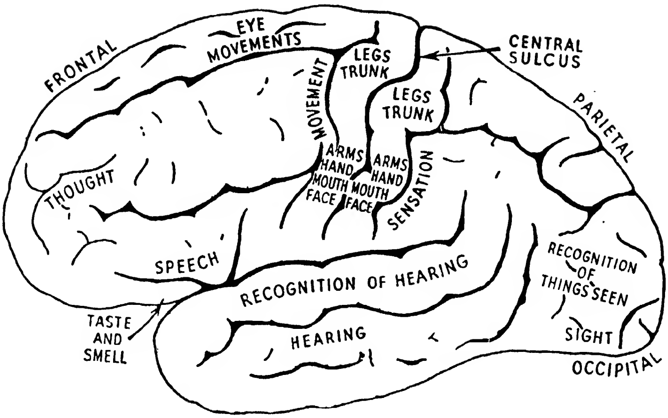


Fig. 51. *Cerebral hemispheres seen from left, showing areas for sensation, motor impulses, recognition, thought.*

the man can see an object but not recognize it; (*d*) the frontal lobes and not much may happen except that the person becomes antisocial. If the motor area is damaged then motor paralysis results; trouble in the finger area (see Fig. 51) produces loss of the use of the fingers on the *opposite* side of the body.

In human affairs, where there is a concentration and centralization of power, that power passes into the hands of one person—prime minister, president, etc.; but we do not find this so in the nervous system. There is no one grand presidential cell to which all sensory impulses are relayed and whence all orders for activity come. A complete democracy is the principle: thousands and millions of nerve cells in the cerebral hemispheres, working together and in harmony, rule the functions of the body. Some progress has been made in tapping the minute electric currents set up when brain cells are active and in unravelling the methods by which these cells are made to work harmoniously.

The unit structure in the nervous system is the neurone (see Fig. 52) which is the name given to the nerve cell and all its branches (dendrons and axon). The dendrons are short twiggy branches which keep the cell in contact with its neighbours. The axon is a highly developed branch, with insulation, which carries the message from the nerve cell to cells (nerves or muscles or glands) it may be some feet away. Think of the motor cells in a giraffe's cerebral hemispheres which govern the movement of the forelimbs. Their axons must run from the brain down to the swelling on the spinal cord where the nerve cells which run to the muscles of the forelimbs lie.

Reflexes

Nerve cells do not necessarily possess axons, but though the fundamental nervous structure is a

neurone, the unit of activity in the nervous system is the *reflex*, and the underlying structure is the *reflex arc* (Fig. 53). Among typical examples of simple reflexes are the following:—

(1) A painful stimulus of the gums causes a flow of saliva. (A flow when you see salted olives is not a true reflex, see below.)

(2) If an object (even a soft harmless snowflake) comes close to the eye, the eye is blinked.

(3) If the white, or if the cornea of the eye is touched, the eye is blinked (corneal reflex).

(4) Any part of a limb being damaged, such as by treading on a pin or a piece of glass, causes the limb to bend at all joints (flexion reflex).

(5) Tickling the skin on the area

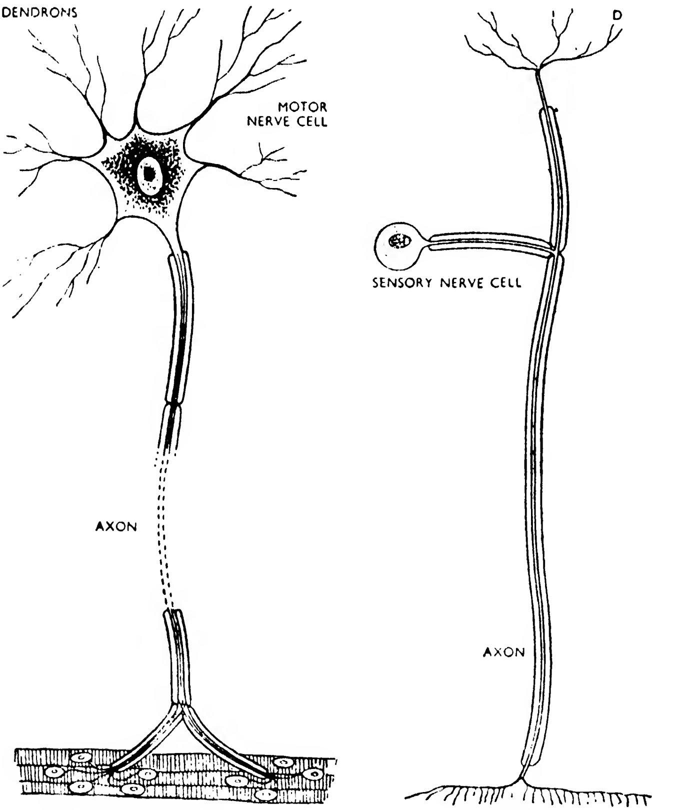


Fig. 52. *Typical motor and sensory nerve cells: (left) motor neurone; (right) sensory neurone. Note the respective end plates and end organs.*

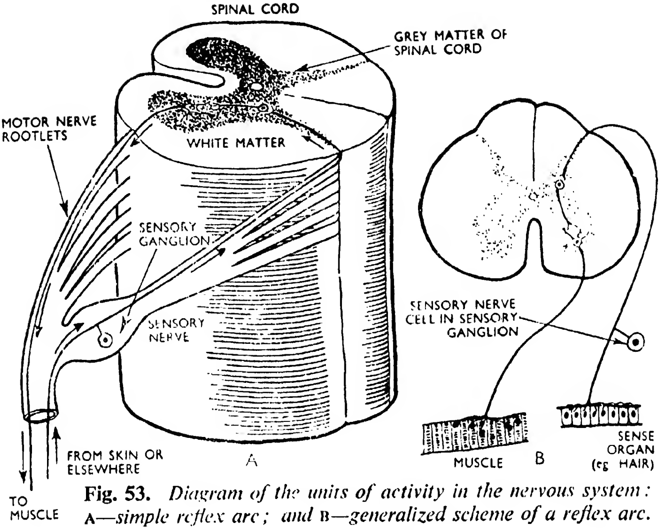


Fig. 53. *Diagram of the units of activity in the nervous system:* A—*simple reflex arc; and* B—*generalized scheme of a reflex arc.*

between the shoulders in a puppy, or an old dog, causes it to bring up a hind leg and start rhythmic scratching (scratch reflex).

There are two types of reflexes: (1) Inborn, inherited, and "unconditioned"; and (2) individual, learnt by education and "conditioned." Man is born with two main reflexes —to cry and to suck—and all the reflexes of breathing, coughing, sneezing, blinking, swallowing and emptying the lower end of the gut and the bladder. Later developed are the reflexes of standing, walking and so on. On these reflexes he builds up a huge number of conditioned reflexes, such as salivation on seeing or smelling salted olives, feeling hungry when the dinner bell goes, automatic balance on a bicycle, emptying the gut at a particular time in the day. The unconditioned reflex needs only that the reflex arc should be intact. For a conditioned reflex to occur, the highest part of the brain (the cerebral hemispheres) as well as the reflex arc, must be intact and able to function.

The reflex arc in its simplest form consists of the following: (1) a sensory end organ—say a touch spot or pain spot in the skin; (2) a sensory nerve running from that spot into the nervous system (see Fig. 52); (3) a sensory nerve cell (see Fig. 52) to keep that nerve alive; (4) a junction (called a synapse) between the sensory nerve end and a motor cell (see Fig. 53A); (5) an axon running out from that cell and making connexion (see Fig. 52) with a muscle or gland.

The sensory nerve ending is stimulated. This evokes a nervous impulse which rushes up the nerve at some one hundred yards a second;

this impulse breaks down the resistance at the synapse and awakes the motor cell to activity. The motor cell fires off a new nerve impulse down the motor nerve. When it reaches the muscle it causes it to contract. This is the simplest imaginable reflex (and reflex arc, see Fig. 53B), but it is certain that in life things are more complicated. The sensory nerve does not run only to one set of motor cells but also to those which, if active, would cause an opposite movement (extension of a limb and not flexion). It also runs to the flexor and extensors of the opposite limb, and to those of the upper or forelimb, and also on into the brain. It may play upon the centres in the medulla which control breathing and heart rate and blood-vessel tone. Finally it may play, through relays, on the grey matter in the mid-brain, in the thalamus and in the cerebral hemispheres. There are possibilities of reflexes at each level, and, at the level of the rind (cortex) of the cerebral hemispheres, of the development of new reflexes (the conditioned reflexes).

Let us take an example. Giving food to a dog causes it to salivate—an ordinary reflex. Repeat, but just before feeding sound a tuning fork of 256 vibrations per second (middle C on the piano). Repeat ten times, sounding the tuning fork each time. Now sound the tuning fork alone, without feeding. *The dog now salivates* to the sound—it has learnt a new reflex—a conditioned reflex. For this learning of a new reflex, the cerebral hemispheres must be intact.

Now Man's cerebral hemispheres

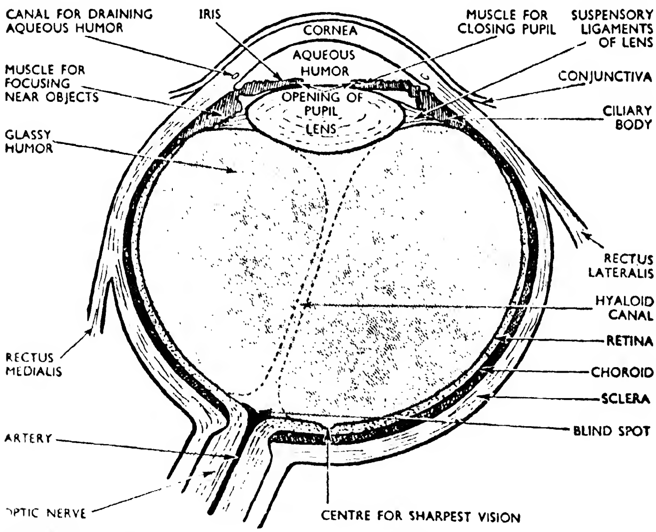


Fig. 54. *Horizontal section through the human eyeball, showing the anatomical features and the disposition of the optic nerve.*

compared with those of even the highest ape are magnificent in size and in power of learning new reflexes. His brain is eminently educable. He can build conditioned reflex upon conditioned reflex indefinitely. In fact, people who believe that life and conduct can be explained on mechanical grounds maintain that all our activities—even to composing a symphony or writing *Hamlet*—are due to conditioned reflexes built up on a basis of inherited reflexes. Condition a boy in brutal surroundings and his character will be brutalized. On the other hand, condition him in humane surroundings and his reflexes (his character) will be social.

There is hope for humanity, even in materialistic theories, so long as education is in the hands of the wise and humane. If it be maintained that our character depends on heredity and acquired conditioned reflexes, at least let us see that the conditioned reflexes are beneficial to the whole of society.

Sensory Apparatus

A few words about the sensory apparatus at the beginning of the reflex arc are necessary.

(1) *The Eye* (see Fig. 54). This is an optical system (something like a camera) to focus an image of an object on specialized nerve endings spread out in the retina of the eye. As an optical instrument it is a poor one, making an image of a window on the retina something as in Fig. 55, but attached, as it is, to a brain which can learn and interpret, the combination beats most manufactured cameras for accurate perspective.

The important curved surface in the eye is the cornea, and if it is not regularly curved we are astigmatic (most of us are slightly so). If the eyeball is too *long*, we are short-sighted, and we cannot see things clearly if they are more than a few feet away. If the eyeball is too short, we are long-sighted, so that we see things in the distance clearly but not things close to.

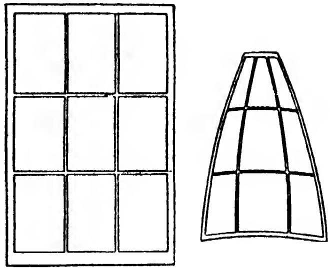


Fig. 55. *Diagram showing (left) a rectangular object and (right) how that object looks when focused on the retina of the eye.*

The second important focusing surfaces are those of the lens. In youth this structure is elastic, and swells into a more globular form when the muscles holding its suspensory tackle contract. So youth can focus things near to. Old-age vision, which begins at forty-five, is due to the lens losing its elasticity. Even though old people contract those muscles, the lens will not bulge and focus near objects. Therefore the old take to spectacles which have a bulge on them.

(2) *The Ear* (see Fig. 56). This consists of three parts: (*a*) the external ear, consisting of pinna (having decorative function only in Man), and a tube (meatus) which conducts sound to a membranous drum; (*b*) the middle ear, consisting of an expansion at the upper end of the Eustachian tube bridged by

three tiny bones (ossicles); (*c*) the internal ear where the sensory apparatus is situated. The internal ear is of two parts the vestibule and the cochlea. The vestibule has three semicircular canals in it, and two small sacs (the utricle and saccule). The canals give data about our movement in space; the two sacs about the position of the head in space. The vestibule has to deal with balance. When, by some chance due to rotation, alcohol or disease, it sends confusing messages to the brain, vertigo (giddiness) results.

The cochlea, a coiled structure like a snail, contains the end organs stimulated by sound; those responsive to high notes are at the lower end, and those to low notes at the higher end. Deafness may be due to wax in the meatus impeding the movements of the ear drum; to faulty conduction of vibration across the chain of ossicles to the oval window opening into the inner ear, and to degeneration of the nerves in the inner ear.

If the semicircular canals are attacked the person suffers from severe attacks of giddiness; if the cochlea, he becomes deaf. Deafness due to wax can be cured by any doctor; the other troubles are usually incurable.

(3) *Smell and Taste.* These are usually confused. Smell arises from the stimulation of a tiny patch of nervous tissue high in the nasal mucous membrane. Taste arises from stimulation of the taste buds of the tongue.

There are only four tastes: Sweet and, conversely, sour (these arise from the front of the tongue), bitter (the back of the tongue) and salt (general, all over the tongue). Odours are many and various. The sense of smell is very deficient in Man, when compared with that of animals, but none the less it is the chief sense stimulated by a good meal. Without a sense of smell, life, and particularly eating and drinking, would be much less interesting.

(4) *Touch.* The skin, spread out over the body, is beset with myriads of sense organs. But these are not distributed evenly, nor is the sensation evoked from each one the same. One spot will react to heat and another to cold; some purely to touch, others to pain. Two observations may intrigue the reader. Though he can feel the two points of a pair of dividers as two if they touch the skin simultaneously at one twenty-fifth of an inch apart on the tip of the forefinger, they have to be an inch apart at least on his back. If a cold spot is stimulated with a very hot rod it may evoke a sensation of cold!

(5) *Kinæsthetic sense* (or a sense of movement and position in space). Every normal person knows where each part of his skin is, without looking at the place in question. He can find his mouth in the dark. This is due not only to sensory apparatus in the skin and tendons, but to special sense organs in the muscles which apprise him of exactly how much those muscles are contracted. Though denied for long this muscle sense is now accepted as a fact by physiologists and psychologists. All sensory impulses from the skin and muscles travel by sensory nerves to the central nervous system. Within it the temperature and pain sensory impulses run together, while the touch impulses travel by separate paths. All ultimately get to the

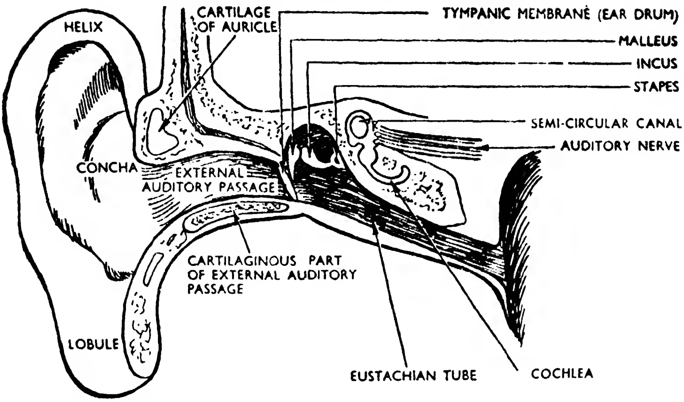


Fig. 56. *Part-section of human ear showing how sound impulses are conveyed to the auditory nerve.*

optic thalamus, whence all but the pain impulses are relayed to the cerebral hemispheres and reach a convolution just behind the motor areas (see Fig. 51). Pain is not represented in the hemisphere but stops short at the thalamus. How we localize a pain in, say, a finger is not clear, but it must be supposed that it is due to the accompanying touch impulses.

Integration by Chemical Means

A country has other means of integration than by telegraph, telephone and radio. It is integrated by its roads, its railways, its omnibuses and its postal services. These are slower means of integration than the electrical methods. Similarly the body is integrated by its circulatory system of blood and lymph. The body posts chemical messengers called hormones into the circulatory system to bring about changes elsewhere for which there is no immediate hurry. Thus, all the mammary glands of a bitch develop at the same rate, even if all nervous communication between them is cut. All the parts of a growing child grow at a definite, controlled and co-ordinated rate. All the signs of puberty appear in the different parts of the body at about the same time within a few months.

For this integration a set of internal secretory glands which secrete hormones into the blood have been developed. The main glands (see Fig. 57) are as follows:—

(1) *Pituitary gland.* This is situated at the base of the skull, and controls, among other things, the rate of growth of the bones, the onset and maintenance of sex activities, the flow of milk from the mammary glands and the concentration of the filtrate from the blood in the kidneys to form urine.

(2) *Thyroid gland.* This is situated just over the Adam's apple, and it controls the rate at which the cells of the body burn up combustible material (a person with under-active thyroid feels the cold; with an over-active

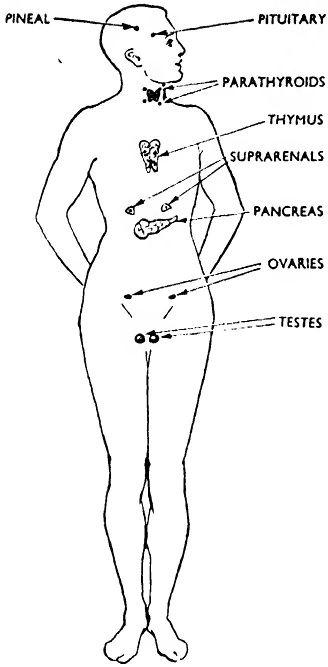


Fig. 57. *Diagram showing the disposition of the endocrine glands in the human body. The thyroid gland is between the four parathyroids.*

thyroid he is always too warm). It is controlled partly by the pituitary gland and also influences the sex glands.

(3) *Parathyroid glands.* These are imbedded in the thyroid, and they regulate the amount of calcium in the blood.

(4) *Thymus gland.* This is close by the breast bone, and it appears to delay the onset of sex activity.

(5) *Pancreas.* This, apart from its function in secreting ferments into the alimentary tract, secretes a hormone into the blood called *insulin*, which enables the cells of the body to burn glucose (when defective the person suffers from sugar diabetes, and insulin must be given to him artificially).

(6) *Suprarenal bodies.* These are glands perched on the kidneys, which (*a*) control the amount of salt (sodium chloride) excreted by the kidneys and alter sex manifestations, and (*b*) secrete adrenaline into the blood stream, which enables the person to meet the vicissitudes of life.

(7) *Sex glands.* Apart from manufacturing sperm and ova, these also secrete into the blood hormones, which produce male characteristics in the male and female characteristics in the female. When a female is pregnant, a hormone presides over the changes which take place during pregnancy.

It is a fascinating subject and by no means has the last word been said and written about it. We owe our personalities as much to these internal secretory organs as to the nervous system we inherit. They have been dubbed "the glands of destiny," but that is going somewhat far and beyond the evidence that has yet been accumulated.

Species and Varieties

When we look at animals and plants even the youngest of us can see that there are natural groups, each presenting definite likenesses among its members. Lions and tigers are more like cats than they are like dogs, and wolves, jackals and foxes are more like dogs than cats. In the same way roses are more like the blossom found on apple and may trees than like dandelions and daisies. It is the work of the naturalist to investigate these like-

nesses and differences and to work out their classification.

He arranges them in families, genera, species and varieties. The dog family comprises the dog, fox, jackal and wolf. The foxes form a genus of this family. Among the foxes we can differentiate between the common red fox, the Arctic fox, the Bengal fox, the Fennec fox and so on. Each of these we call species. In the same way we put the yellow water iris and the common garden flag in the same genus, but call them separate species. Within the species there is considerable variation, particularly where Man has taken a hand in selection. The toy terrier and the St. Bernard are both dogs, and the varieties of roses and garden irises evolved from a single species are innumerable. We speak of the individual sorts as varieties.

Quite where the species end and the varieties begin is a difficult problem. Once upon a time it was thought that the distinction lay in the possibility of cross breeding. It was said that two species could not cross breed indefinitely. Either a mating was infertile, or if fertile the offspring showed signs of incapacity for reproduction. Thus the cross between a horse and a donkey is the sterile mule, and the cross between a canary and a finch is an infertile "mule" canary. Similarly the cross between a pink and sweet william is sterile. But that distinction has broken down because it has been found that in some cases animals and plants which are unhesitatingly classed as belonging to different species, interbreed freely. Hooded crows interbreed with carrion crows and their offspring are fertile. Tree lupins and the common garden lupin interbreed and have produced the magnificent and fertile Russell lupin. White, black, yellow and red skinned human beings interbreed freely and so are usually termed varieties of Man (*Homo sapiens*). In fact, biologists have been driven to say that "a species is a group of animals (or plants) that has been defined as a species by competent systematists." Competent systematists can, of course, differ from each other. They may divide brambles and wild roses into as few species as two or as many as sixty-two!

This shading off of varieties into species is what might be expected on the assumption that living organisms have evolved from a common stock, but not on the old-fashioned belief that each species was due to a special creation, fixed and frozen for all time from the beginning of time. In all that has been written above it has been assumed that living things have evolved from a common stock—in other words the theory of evolution has been accepted.

Evolution

The evidence in favour of evolution is summed up as follows:—

(1) *Geology*. We have now a means of estimating the age of rocks and we can safely say that the earliest well-preserved fossils of living organisms—the trilobites—existed more than 500 million years ago. Fish appeared somewhere less than 400 million years ago; land plants 360 million years; trees about 300 million years; amphibia (frogs, etc.) somewhat later; reptiles about 200 million; mammals about 150 million years; birds roughly 120 million years; placental mammals some 60

million years ago; and modern birds between 30 and 60 million years ago.

(2) *Similarity of Plan.* The vertebrates, for example, are built upon the same plan, and this plan extends to details as well as general structure. The flipper of the dolphin and seal, the wing of a bird, the forefoot of a horse, the wing of the bat and the hand of the ape present remarkable likenesses. This is best explained by the theory which states that they have all developed by modifications from an ancestral forelimb.

(3) *Missing Links.* In geology, as investigations of fossils are expanded, we continually find fossil remains which provide links between an animal (or plant) as we see it today and the animals (or plants) millions of years ago from which it developed. Perhaps the best example is the horse. In geological data, we can, as it were, watch the development of the modern horse from a creature about the size of a dog and having three toes. We can see the suppression of two of the toes till they form the splint bones of the foot of the modern horse. The original dog-sized animal is, or was, something we should call a horse, it is true—but how unlike the modern horse! Fossil remains have given us missing links between reptiles and birds, and between the present-day elephant and his ancestors away back 30 million years ago.

(4) *Vestigial Structures.* We find in modern animals vestiges of structures which fulfilled a useful purpose in their ancestors, but which have become useless, or even a nuisance, in the animal of today. A good example is the splint bones of the horse. Another is the possession of cilia by the male cell in the maiden-hair tree.

(5) *Embryology.* As the young of animals are watched in their development from the fertilized egg cell to the mature form we see that at the earlier stages they are all very much alike. The early embryos of cat, hen and snake are so alike that they are hard to tell apart. Moreover the heart, main arteries and neck regions are built on the same plan as a fish. The cat-embryo's heart is not divided into four chambers, but is like the heart of a fish, and the neck is furnished with gill slits. This leads to:—

(6) *Recapitulation.* The embryo recapitulates—not fully it is true—its ancestral history. A mammalian embryo appears at one stage of its history to belong to the fishes. It is not until later that it differentiates into a true mammal. Fossils suggest that the modern horse has arisen from a three-toed ancestor. All these observations, and multitudinous others, can most simply be explained by the assumption that animals and plants derived from a common stock in the dim geological past. In fact, this theory dominates the whole of biology and has extended its influence into all our ways of thinking today not only of zoology and botany but into other much remoter subjects, such as theology. It is, of course, applied to Man also.

Fossil remains show that some

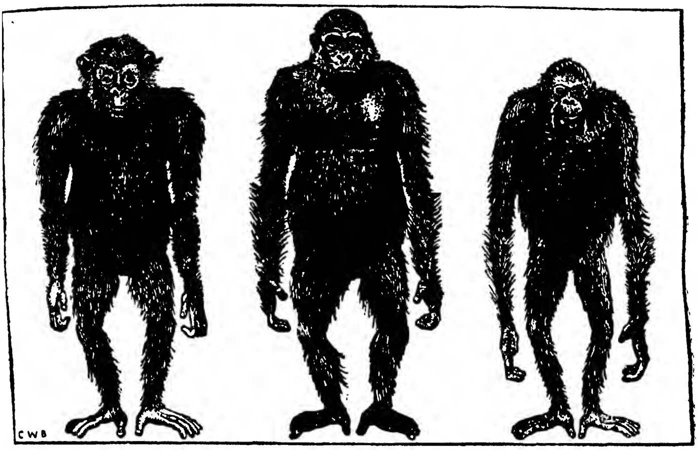


Fig. 58. *Diagram showing the bodily resemblance of the chimpanzee, gorilla and orang-utang. Note their likeness in bodily form to Man.*

creature bearing human characteristics appeared on the earth about 10 million years ago, long after the first mammals appeared. Man is a vertebrate, a mammal and a primate, i.e. he is built on the same plan as a frog, a dog and a monkey. He is more like a dog than a frog and more like a monkey than like a dog. He differs less in his make-up from an ape than apes from other monkeys. Man in his structure and development is zoologically akin to the chimpanzee, the gorilla and the orang-utang (see Fig. 58).

Man's Vestigial Characteristics

There are missing links, too, between man and his ape-like ancestors. Fossil remains have been found, in Sussex, Java, Africa and the Continent of Europe, of animals which were not apes but possessed human characteristics—the large skull cavity, the freely movable neck, the erect posture. One of them, though probably not directly on Man's ancestral line, buried its dead with their hunting weapons, which suggest that it (he?) had some dim idea of immortality.

Man possesses many vestigial characteristics, such as muscles to move the hairs of the body. "Goose-flesh" has no advantage to Man. It does not keep him warm, as erecting the hair in a furry animal or the feathers in a bird does; nor is it likely to frighten his enemies. He has muscles to move his ears, though the pinna of the external ear has no value in telling him whence a sound is coming. He possesses a small useless nictitating (winking) membrane in his eye (in animals it is a functioning organ, and it sweeps across the eyeball from time to time, moistening it and wiping it clean). Some men, and fewer women, possess a point to the ear, bespeaking animal ancestry. Finally, Man in his embryology exhibits recapitulation.

At an early stage, Man has gill clefts, a tail with muscles to wag it, and a furry coat. A newborn

baby can support its own weight like a chimpanzee baby; and it has prehensile (grasping) toes like a monkey. Moreover, the chemistry of Man's blood shows likeness to that of the monkeys. If a rabbit is injected from time to time with small quantities of human blood it gains the power of precipitating human blood. At the same time, it also gains a power of precipitating monkey blood, but not the blood of other animals—the closer the cousinship to man of the monkey concerned, the greater is the power of precipitation. There is also a rare inherited characteristic of human blood which is closely allied to that of the rhesus monkey. Thus the evolutionary theory includes Man in its ambit.

Origin of Species

There is no satisfactory theory to explain why evolution has taken place, but there is much magnificent work to show how it takes place.

Darwin thought that the inevitable chance variations which occur in all living things were preserved if they proved of advantage in the struggle for existence. No two peas in a pod are exactly the same size. It was originally believed that if, say, a small sized pea gave a better chance of survival to the pea plant, then the large peas would diminish in number and the small peas increase till they dominated the situation. Thus natural selection would wipe out the one and preserve the other. By the adding up of small chance variations a new species would arise—hence the origin of species. But investigation has shown that these chance variations are not inherited and we have to look elsewhere.

Since the beginning of the twentieth century intensive work has been done on the sports (freaks of nature) which suddenly appear in living organisms and which are inherited. The ordinary grey-brown rabbit may throw a white or a black sport. A blackbird may have white offspring. Human beings may suddenly throw a sport having no pigment (they are called albinos, and have white hair, pink eyes and a skin which will not sunburn). Other sports are deaf-mutism, failure of the blood to clot (hæmophiliacs or bleeders), and possibly the allergic diseases, such as asthma, nettlerash and hay fever, are due to "sport." Sports occur notably in cousin marriage among human beings.

Sports (or mutations as they are called) arise from the alteration, malformation or dropping of a gene (see page 163). If the sport is advantageous, the animals or plants possessing it beat the others in the struggle for survival. Very often sports are the reverse: they are disadvantageous and as such would be stamped out by natural selection. The origin of species seems to be the result of the adding up of advantageous sports. Thus geneticists (scientists who investigate inheritance) are back in the old Darwinian attitude of mind, which was supposed to have been discredited.

X-rays and poisons have been used to alter genes and produce sports artificially. Flowers mutated artificially are on the market and the future will present us with many artificially mutated animals also.

Mendel's Theory of Inheritance

The first work on the factors governing inheritance was carried out half-way through the nineteenth century, but it was buried in an obscure Silesian scientific journal,

only to be disinterred at the turn of the century. The Abbé Mendel, of Brno, worked on peas and deduced rules which have been found to be true not only for plants but for animals. There is a master plan for inheritance embracing every type of living thing investigated. If a yellow culinary pea is crossed with a green pea the offspring are all yellow. If these are allowed to inbreed—peas, sweet peas, wild peas normally inbreed—the results are not all yellow peas. One-quarter are green peas, and three-quarters are yellow. But of these three-quarters one-third are pure yellow and throw nothing but yellow offspring, but the remainder are hybrids and throw offspring one-quarter of which are green and three-quarters yellow, and this goes on indefinitely generation after generation.

From experiments such as this Mendel deduced the rule that the male cell or the female cell can carry only one character, i.e. yellowness or greenness. If a "yellow" male mates with a "green" carrying female the result is a hybrid in which the yellowness dominates the situation but the greenness retires into the background. When these plants form sex cells they can pass either "greenness" or "yellowness" into such cells but not both at the same time. The gametes (sex cells) are pure for greenness or yellowness. This is summed up in the phrase the "purity of the gametes."

Let us apply this to something in human inheritance. Blue eyes and brown eyes behave like greenness and yellowness in culinary peas. If a person in whose ancestral tree there have never been blue eyes marries one with blue eyes, the children will all have brown eyes. Should two brown-eyed people who came from parents both having brownness and blueness in their inheritance marry, three-quarters of their offspring would have brown eyes and one-quarter would have blue eyes, but of the brown eyes one-third would be pure brown and the remainder be impure brown, that is they have the power of handing on blue-eyedness. It is interesting to work out pedigrees of eye colour in one's own family, and deduce who is pure brown, impure brown, and blue (blue is always pure). Thus the writer's parents were both blue-eyed and so he and his brothers have blue eyes. He married a blue-eyed woman and his children are all blue-eyed. But one of his brothers married a pure brown-eyed person and his children are "impure" brown-eyed. One child married a pure brown-eyed person and the offspring are brown-eyed, but there is a chance that should any of these marry either a blue-eyed or an "impure" brown-eyed person some of their offspring will have blue eyes.

A set of diagrams will perhaps make this plain. Let us consider the cross between pure yellow peas and pure green. The gametes of the green peas carry one dose each of green and those of the yellow one dose of yellow.

Gametes of the yellow peas

		Y	Y
Gametes of the green peas	G	GY	GY
	G	GY	GY

Thus, the offspring of union are all GY, that is, every seed contains a yellow and so appears yellow.

Similarly with blue eyes crossed

with brown eyes it can be shown thus:—

Gametes of the brown-eyed

		Br	Br
Gametes of the blue-eyed	Bl	Bl Br	Bl Br
	Bl	Bl Br	Bl Br

Thus, the offspring of the union are all Bl Br, that is, every child carries both blue and brown and so appears brown-eyed.

Suppose impure brown-eyed people marry. Then each gamete can carry only blue or brown and not a mixture, as follows:—

Gametes of the male parent

		Bl	Br
Gametes of the female parent	Bl	Bl Bl	Bl Br
	Br	Bl Br	Br Br

Inheritance of the children is such that one-quarter are Bl Bl (pure blues), one-quarter Br Br (pure browns), and the remaining 50 per cent are Bl Br or "impure" browns; in fact the inheritance works out exactly as with culinary peas!

Geneticists believe that these laws apply not only to such superficial things as the colours of seeds and flowers and eyes but to every inheritable character, though they do not yet attempt to explain why one person is a Roosevelt, a Churchill, a Stalin or just you or me. They believe this because they have established the fact that when living cells divide to form new cells they divide in a way that gives a physical basis for Mendel's laws of inheritance. A cell does not just divide into two in a haphazard way, but in a definite sequence of events.

Each cell has a nucleus, as we have seen. Just outside this nucleus is a little body, the centrosome (see Fig. 59A). This divides into two and each part moves to an opposite pole of the nucleus (see Figs. 59B and 59C). Then the nucleus breaks up into threads called chromosomes—a constant number for each species (Man has forty-eight). These threads arrange themselves at the equator of the old nucleus and then each divides into two (Fig. 59D). One of each pair moves off towards a centrosome (Figs. 59E and 59F) and then the threads recombine to form two new daughter nuclei (see Fig. 59G). Lastly a new cell membrane forms between the two nuclei, and we now have two cells (Fig. 59H).

This is true for the ordinary cell, but what about the sex cells? If these do not get rid of half their chromosomes, when two sex cells unite the new cell would have twice the right number of chromosomes. They do halve the number of chromosomes (see Fig. 60). Each body cell has its chromosomes in pairs, one deriving from the male parent and one from the female. When sex cells are formed into two, the individual chromosomes instead of splitting wander off, one of a pair to one pole and the other to the other.

It is chance which way they go except that never do the pairs keep together.

If there be two J-shaped chromosomes in the parent cell, one goes towards one sex cell and one towards the other. It might happen that all the chromosomes contributed by the female parent should go off to one sperm cell and all those from the male parent to a second sperm cell, but that is unlikely in man with his twenty-four paired chromo-

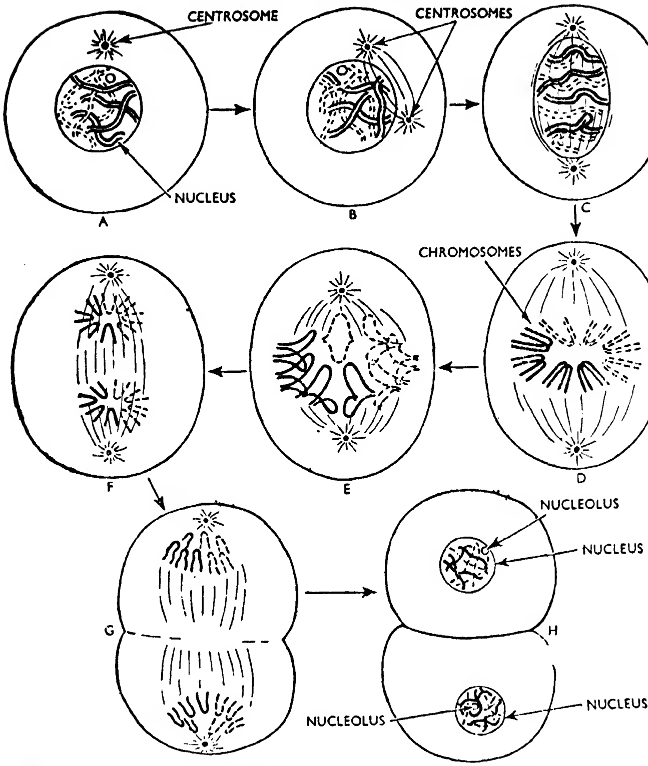


Fig. 59. *Diagram illustrating the sequence of nuclear changes which take place in a dividing cell, as described in the text on page 160.*

somes. It is chance which determines whether a man passes on the chromosomes inherited from his father or his mother or a mixture of both to the individual sperm cells. The main points to remember are that the number is halved and that two members of a pair never pass into the same sex cell. That is exactly how the Mendelian characters behave. No gamete can hand on both yellowness *and* greenness, and one is led to the conclusion that the chromosomes carry the Mendelian characteristics.

Since this dawned on the minds of geneticists, mainly owing to work by Morgan in New York, intensive research has made the suggestion almost a certainty. In the plants and animals chiefly investigated—maize, fruit fly, grasshoppers, pigs—they have found which chromosome carries which character. For example, we know that in the fruit fly one of the chromosomes which

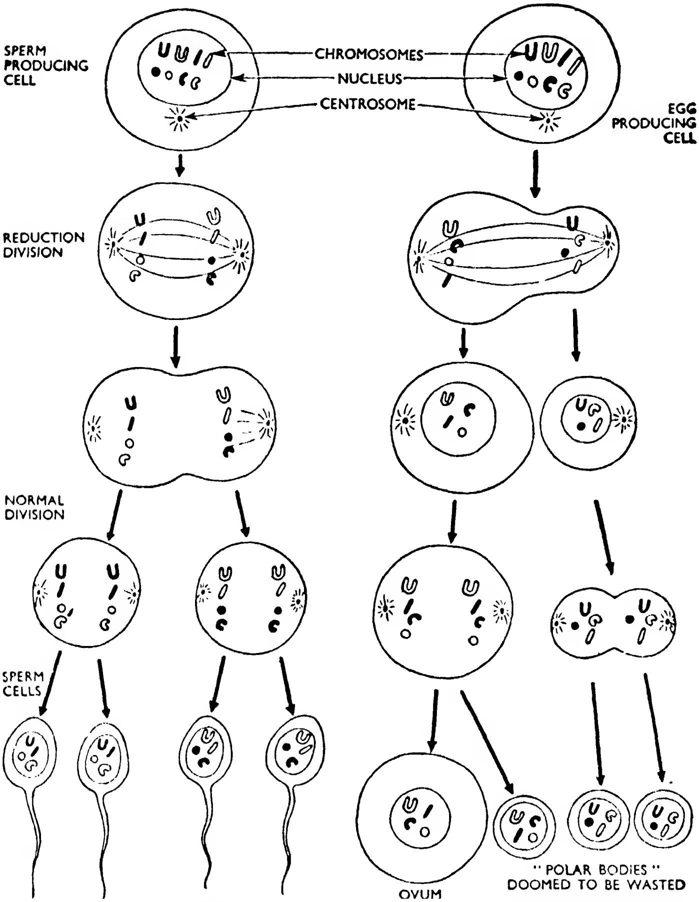


Fig. 60. *Diagram illustrating the halving of the number of chromosomes in the formation of sex cells: (left) male and (right) female.*

carry sex determination is J-shaped in the male, but straight in the female. If a sperm carrying a J-shaped sex chromosome unites with an ovum, the offspring is bound to be male; if it carries a straight chromosome the offspring will be female. In Man one of the paired sex chromosomes is smaller than the other. If this small chromosome passes into a sperm and this fertilizes an ovum the baby resulting will be a boy; if the larger of the pair passes into a sperm and this fertilizes an ovum the baby will be a girl. If we could separate the

two types of sperm according to whether they carry a small sex chromosome or a large one—and this is not beyond the bounds of possibility—we could make certain the begetting of boys or girls at will.

If anything so fundamental as sex can be carried by chromosomes, then it is not astonishing to find that such things as colour-blindness and lack of the power of blood to clot are considered to be Mendelian characteristics and carried by the chromosome which determines femaleness (colour-blindness is passed on by the female, but appears practically only in the male). In fact, geneticists are convinced that all our inheritance is Mendelian, that our characteristics are handed on via the chromosomes, and that each chromosome carries a number of Mendelian characters each at a definite point as a chromosome.

The sphere of influence on the chromosome for any one character is called a gene, and our inheritance is a matter of genes. Maps of the genes on the fruit-fly chromosomes are progressing rapidly towards completion. Some day there may be a complete map of the genes on human chromosomes, though so far we know little.

All this sounds extremely theoretical when put forward in this condensed way. It is, but the value of a theory is in its uses. A good theory helps to explain, to predict and to act on the predictions.

This Mendelian theory of the purity of the gametes enables us to explain why the black Aberdeen Angus breed of cattle throws red offspring; why an apparently pure bred white-haired bitch throws smooth-haired offspring; why white children are sometimes born to black parents; why consanguineous marriages, i.e. marriages between blood relations, are more likely to produce abnormalities than marriage outside the clan. It enables us to predict what this or that mating will result in. Most telling of all, it enables the agriculturist to produce new breeds of plants and animals with specific characters.

The most famous examples of the breeding of new varieties of plants are Little Joss and Yeoman wheats—smut-resisting and upstanding plants—and a variety of disease-resisting sugar cane with 20 per cent more sugar in it. We know, further, that milk production in cows is sex-linked and is handed on by the bull (this affords agriculture the chance of increasing the milk production enormously in a few years by artificial insemination from pedigree bulls). That Mendelism works in practice is its vindication.

Relation of Biology to Society

Biology has been, and still is, eclipsed in public estimation by the important sciences of chemistry and physics. These latter offer more obviously concrete prizes than biology. However, make no mistake about it, for Man, biology is, in the long run, the paramount science, since society is biology in action in Man. Therefore every schoolmaster, every nurse and physician, every priest and minister, every lawyer and every politician should have a thorough grounding in the elements of biology. It would be better still if every parent were so educated. This is a sweeping statement. It was meant to be. Its justification lies in the practical aspects of biology.

Genes cannot show themselves fully in unhealthy organisms (most

pink sweet peas are alike in autumn however different they were in spring). They must be given a chance to develop to the full. They are as likely to be hidden in the poor as in the rich, so health of the whole population is essential. While the infant mortality is eighty per thousand live births in one class of society and but twenty in another, biology is insufficiently applied, for infant mortality does not spare the genes of genius. While there are typhus-ridden areas of the world no one is necessarily safe in these days of aeroplanes. Despite all precautions some of the medical student volunteers who worked at Belsen concentration camp brought back typhus with them.

Food, of which there is a world shortage, is the prime necessity of the body. So society is based on agriculture, not on the volume of trade, say, in gramophones and cosmetics. And agriculture more and more is applied biological science. It always was applied biology. Modern biology has developed new disease-resisting wheats, sugar canes, tomatoes, etc. By artificial insemination it has the power of rapidly increasing the milk production of any country, for the gene for milk production is passed on by the sire. The biological control of insects—the chief enemy of Man—has opened up enormous prospects.

No one trained in biology is likely to muddle race with nationality and language with either or both. There is no French "race," no German "race," no British "race." Though the French speak a Romance language and the Germans and British, a Teutonic language, their genes are much the same. Kipling's "Lesser breeds without the law" is pre-genetics nonsense. Moreover, much of the stuff written about eugenics is false biology, nor, despite the poets, does war improve the race. In fact, it is dysgenic—it makes for racial deterioration; for war always kills off the young and vigorous members of the community and leaves the weaklings and the elderly to survive and hand on the race.

The raw materials of biology are living—not dead as in chemistry and physics. These sciences, wonderful as they are, cannot hold a torch to biology as a stimulus to the imagination. The way life has thrust itself into every nook and cranny of this earth and the manifold extravagant, beautiful and hideous, creative and destructive forms it has taken, fill the mind with wonder. And wonder, awe, a sense of sublimity are no mean antagonists to the asocial dictator each of us nourishes in his breast.

The body is a commonwealth. We have seen that the biological body is a grouping of billions of cells, all co-ordinated in their activity for the common good. To each is given according to its needs; from each is demanded according to its capacity.

This grouping of billions of cells is integrated, as we have seen, into a whole, and the mode of integration of the body is democratic. Now society, i.e. Man as a body-politic, is in need of integration. It—he—is not integrated while there is a starving peasant in Bengal or a rickety baby in the slums of Glasgow. Fear is not, as tyrants down the ages have thought, the prime integrator of mankind, but—sentimental, extravagant, pious as it must sound, and for some unknown reason the last thing any of us want to believe and act upon—love *is*.

CHAPTER 5

PEOPLES OF THE WORLD TODAY

Interdependence of mankind. Physical differences. British types. Racial types. Africa. Nigeria and Gold Coast. South Africa. Morocco. Egypt. India. China. United States of America. Europe. National traditions. Danubian states. Turkey. The Near East. Palestine. Russia. Mongolia. Communications and civilization. Canada. Japan. Australia. New Zealand. South America. Polynesia. Spain. Sweden. Origin of races.

EVERY citizen of a civilized country today draws upon the five continents for his common needs. From the tropical forests and jungles, from the open prairies and steppes, from the heart of remote mountains, from plantations on the other side of the Earth, the raw materials for our daily needs are carried over the seven seas to our cities.

This means that, through our daily food and clothing, through the tools of our trade and our possessions, we are brought into contact with distant and unknown peoples whose labour has made our possessions possible.

Every day the Negro cotton pickers of the United States of America, the Indian women working on the tea estates of Assam, the South American gauchos rounding up their cattle in the Argentine, the South African fruit farmers, Canadian wheat farmers, Australian sheep and cattle farmers, workers in the oil wells of Persia, coal-miners in Britain and workers in British factories, are bound together by the international economy of modern civilization.

The whole world nowadays is one market place. Men and women everywhere are walking emporia of the world's wares. To know and understand something of the life and conditions of these varied peoples of the world is therefore to come to understand our own life better. To take a peep into the homes and working conditions of people throughout the world is to enrich our own lives, and at the same time to gain a sense of our indebtedness to, and our unity with, the rest of mankind.

People all over the world are much more alike than we sometimes imagine. Scientists today have destroyed the myth that there are great differences between different kinds of people. They tell us, indeed, that no pure races exist in the world. They doubt if pure races ever existed outside the heated imagination of a Hitler.

America is spoken of as "the melting pot"; but Europe has been a melting pot for a far longer time. The British people are generally proud of being mongrels, while Miss Dorothy Sayers has spoken of "the fifty-seven varieties" of peoples in the British Isles. Fig. 1 is a good guide to the predominant racial characteristics of the people who live in those islands. Most peoples on the continent of Europe, however, are even more mongrel than the British.

This does not mean there are no

differences between different types of man. A Boer is different from a Bantu, a Frenchman from a Fijian, an Arab from an American, and an American type of man is most certainly developing in the United States (no one could say that the American type belonged to a pure race!). In Europe it is not difficult to distinguish a Magyar (Hungarian) from, say, a German (Teuton): though if both spoke the same language it might be difficult.

Classification of Races

The "races of men" are simply types differentiated from one another by certain common physical characteristics, such as colour of skin, texture of hair, shape of skull, certain bone formations and so on. When certain combinations of these characteristics seem to be common, or very predominant, among a certain group or groups of mankind, they form the nearest approach we can get to a race of men.

Some scientists, taking certain combinations of characteristics, have classified the races in one way; other scientists, taking other combinations, have classified the races in another way. In two textbooks on the races of Man you may find quite different names and classifications; although there are certain combinations of characteristics which are now generally accepted as marking the main physical differences of mankind.

Taking skin-colour, with a group of other characteristics, Fig. 2 shows how the races of mankind are distributed throughout the world, but it should be borne in mind that certain physical characteristics are common in all races, whereas in Europe, for example, we quite often find greater physical differences inside one of the races than we find between one race and another.

A popular diagram of the races of Man is planned like a tree, with the existing races branching out from a main stem. It may be true, it probably is true, that Man has evolved from a common origin: that is from one stem, one root. We may even think with profit for one moment of the symbolic story of Adam and Eve and of mankind as one human family.

Even if this is so, the symbol of a tree is misleading, because the types of men have not branched off from one another continually, but have met continually after parting. A truer diagram would, therefore, represent the races of Man as a maze, with the paths or branches perpetually crossing and running into one another: blood mingling with blood again and again.

Causes of Type Variations

Scientists now tend to hold that the real differences between men are the product of climate and geographical conditions, with heredity playing only a contributory part; while the social life which men lead causes them to develop differences of mind and spirit: social life including all such things as language, customs, standards of living, religions, political and national histories.

The Jews, for example, though so widely scattered, are held together by traditions which keep them to a great extent apart from any peoples among whom they live, and encourage intermarriage among themselves. Dr. Julian Huxley, Professor Carr-Saunders and A. C. Haddon say the Jews "are held together,

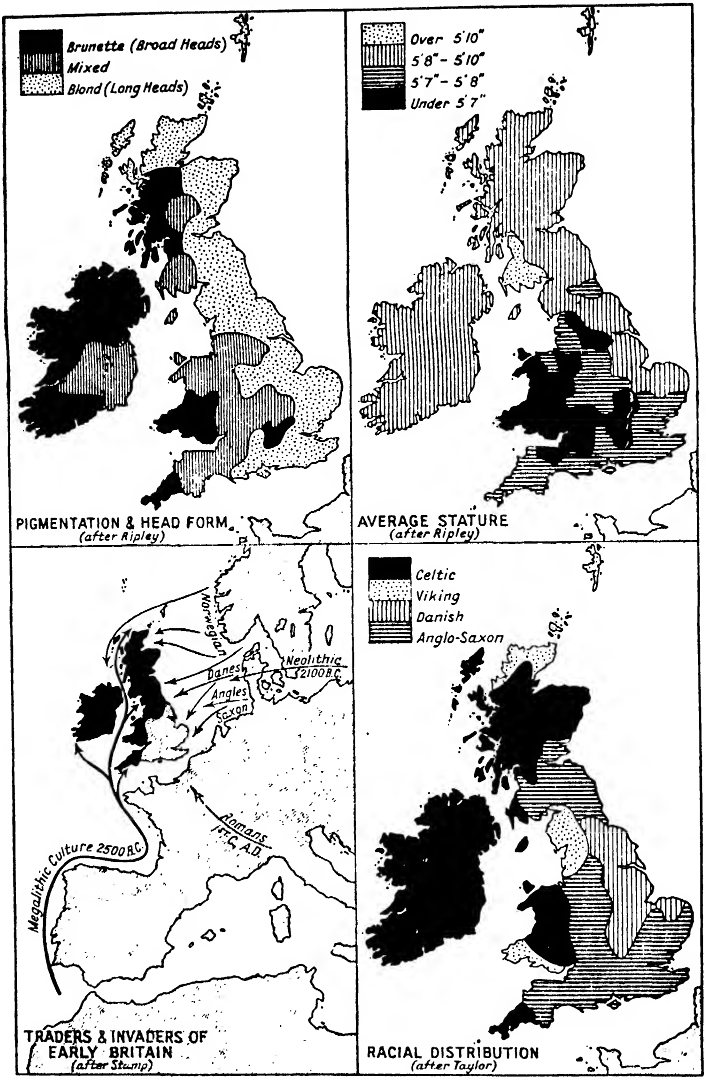
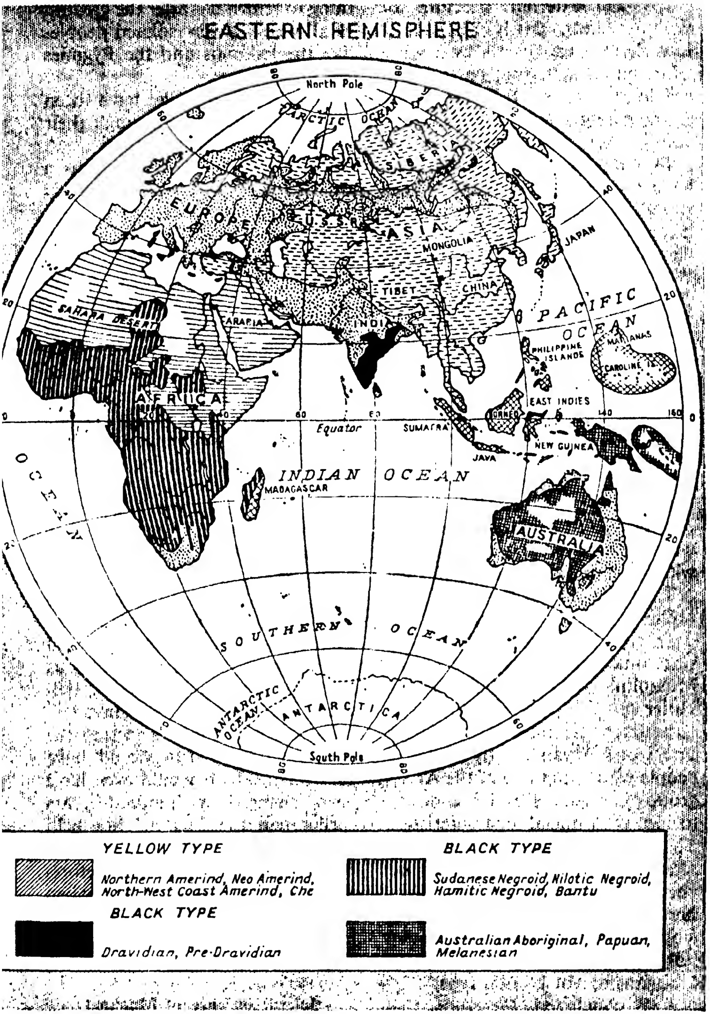


Fig. 1. *Maps showing the distribution of predominant racial characteristics in the British Isles, with (bottom left) the various waves of traders and invaders that contributed to Britain's racial heritage.*

Fig. 2. *Map giving a generalized plan of the present-day distribution of the predominant racial types of mankind throughout the world. Note that the various types are grouped into three main divisions according to skin pigmentation: the white skinned peoples (leucodermi), the yellow-skinned*



peoples (xanthodermi), and the black-skinned peoples (melanodermi). Intermingled with the predominant types shown here there are many smaller groups such as the aboriginal Ainu of Japan, the Bushman of Africa, and Indian communities who are related to the Mongols and American Indians.

partly by external pressure of various kinds, partly by a long historic memory, partly by a sense of common suffering, partly by a religion. These factors, acting through long ages, have produced a common consciousness."

In many parts of China the Jews have been absorbed into the surrounding population so that there is now little or nothing to differentiate them. Before the Second World War, it was said that the German Jews were on the way to absorption into the common German stock but that Hitler's persecutions had given a new lease of life to Jewish consciousness.

The organization of peoples into national states is one prime way to encourage differences of mind and spirit; but the longest national history does not destroy the physical differences of the citizens. In other words, there is no nation today without a mixed population.

The idea of a British, a French, a German, or an Italian race, is a dangerous political fiction which was much used by Hitler and Mussolini and others of their ilk. Hitler spoke of the pure Aryan, or sometimes the pure Nordic type. The word Aryan rightly refers to people who speak one of the Aryan group of languages, and has nothing to do with racial characteristics. The word Nordic comes into the scientific classification of men according to skull dimensions. Even here Hitler was hopelessly wrong, since scientific judgment shows that not more than 60 per cent of Germans are of Nordic type.

It is concluded, therefore, that history and geography create human types, no less than heredity; and that as regards heredity men are all blood brothers (an important thing to remember after the greatest of all wars). Even isolated peoples like the Eskimos and the Pygmies are mixed types.

The British people have been made what they are through their history and their geography. A child in Britain grows up into a vast heritage of social life that moulds him into a distinctive type.

It may be said that the British people are what they are—to take a few highlights—because of Alfred the Great, William the Conqueror, Magna Carta, Shakespeare, Winston Churchill: to say nothing of the daily workers who have laboured for Britain's progress throughout the ages, and the sailors, soldiers and airmen who have won Britain's victories. History helps to create human types.

No less important is geography. The British people are what they are because Britain is an island, and was protected from foreign invasion for a thousand years. It is a sobering thought that, but for the English Channel, Britain would have been invaded in 1940 as Norway, Denmark, Holland, Belgium and France were invaded. No one could doubt then that the history of the world would have been changed. It would even have been changed a hundred years earlier had the Channel not held back Napoleon.

These three factors, therefore, must be taken into account when looking at the peoples of the world today: their physical inheritance; their history; their geography.

Interdependence of Mankind

Above everything, it is true today that men of all nations are bound together economically. No nation is self-supporting, least of all a

small island like Britain, where some forty-seven million people dwell in a land less than six hundred miles long and nowhere more than three hundred miles broad. Of course, such a population is dependent on the five continents and the seven seas for the necessities of daily life. But so is a vast continental nation like the United States of America.

Although the United States of America produces nearly half the world's iron, more than one-third of the world's coal, three-quarters of the world's wheat, more than half the world's cotton, three-quarters of the world's supply of petroleum, and one-third of all the tobacco in the world, she is by no means self-supporting.

Many things, such as rubber, cannot be grown in the United States of America; and, since the Americans use more rubber than any other nation, they are dependent for this vital commodity upon overseas trade. So they are for many other products—for instance, jute, essential for making bags, ropes, cordage and various soft materials. Jute is mostly grown in India and manufactured in Scotland. Thousands of men in the United States of America walk about not knowing that part of their coat-linings has come from India via Dundee.

This is the sort of fact we must establish in our minds, that the peoples of the world are, economically speaking, international citizens of our world-civilization. Or we may say that, since the world is round, and has therefore strictly speaking no beginning and no end, every country is equally a centre of our common civilization.

Since it illustrates ideally the astonishing contrasts of life and progress among men of many kinds who are bound together by the world's economy, let us first consider the peoples of Africa, that great pendant of the main landmass of the world.

Nations of Africa

There are more than two thousand nations and tribes of natives in Africa, each speaking a different language from the rest, each having customs and ideas which differ from the others. Added up, they make a coloured population of over one hundred and fifty millions. When we consider that the white population of Africa is a little over three millions, but that the white man is largely dominant and the ideas of white civilization are spreading—very slowly in many areas—there is food for thought and speculation as to Africa's future.

The native peoples of Africa are endlessly varied (some characteristic types are shown in Fig. 3). They range from the jet-black skinned to the light-brown skinned, from the woolly-haired to those whose straight hair refuses to curl, from the flat-nosed and thick-lipped to the pointed-nosed and thin-lipped, from black-bearded men to men who cannot grow a beard, from brave warriors normally seven feet tall to the tiny, timid Pygmies.

These peoples vary as widely in their culture. There are, for example, the people of the Hausa tribe (they are of Hamitic stock and are Mohammedans) who dwell on the south edge of the Sahara. They keep cattle, sheep and goats, cultivate the soil, make glass, weave mats and baskets, make their own clothes and fashion all

sorts of useful and beautiful things in leather. The Hausa make good stout buildings of stone and earth. They trade with the white men and rule themselves, carrying out their laws through their own courts of justice.

In contrast to the Hausa are the Naron tribe of Bushmen (of Hamitic-Negro stock, pagans worshipping the Moon) who live in and around the Kalahari region in the south. The Naron live on fruits and roots they gather, and on small bucks and hares, the only animals they can hunt or trap. The women build rude huts out of tree branches and grass which they set up in little clusters not more than a mile or two from a water-hole, which they share with the beasts. They cannot live nearer to the water for fear of frightening the beasts away, when they would get no meat at all.

The Naron live with the utmost simplicity. If a family is too crowded in a hut, the bigger boys have to sleep out under the trees. Ostrich-egg shells and rough wooden bowls are practically all the furniture they have, since a family can only possess what its members can carry. They wander off to a fresh water-hole when the fruits and roots are eaten up in one place. The men make simple clothes out of animal skins. The only weapons they have are small bows and arrows tipped with bone. The Naron do not know how to cultivate the soil, nor how to keep animals for use.

Importation of Labour

With this contrast between the Hausa and the Naron in mind, a great deal of the picture of Africa becomes plain. When white men first came to settle in the continent, and found the soil good for growing sugar, cotton, coffee and other crops for export, they had difficulty is persuading the natives to work for them. Plantations could not be developed without the aid of native labour, but the native tribes were self-contained, self-supporting, and would not alter their way of life save under compulsion.

Thus the Kaffirs lived in their own kraals, which were like independent states on their own. A kraal (see Fig. 4) is a village of huts surrounded by a stockade. It is ruled by a black chief. The people of a kraal claim the adjacent land for breeding their cattle, and which they used to defend against the warriors of other kraals or against any other invader. It was these kraal warriors who first fought the British and Dutch farmers.

The white men had to import Indian labourers from over the ocean to open up their plantations; these Indians worked hard, settled, grew prosperous, and eventually became landowners with their own farms and shops; they became a serious rival to the white men. There are today half a million Indian settlers in Africa, who add to the racial mixture and problems of the continent.

But not all the African natives were averse to co-operating with the whites; and throughout Africa today the steady advance of European civilization is to be seen.

The black folk of Africa are very different from the brown people of India who have a civilization of their own and a long history to look back upon. The mass of Africans have no civilization and no history. Their past is a blank to them, and their religions are full of magic and fear. They had no reading and

Fig. 3. *Some characteristic African natives, showing the wide variety of types found in the continent. Compare the broad nostrils and round face of the Masai girl with the sharp features of the Galla witch doctor; the curly-haired and bearded Abyssinian with the shorn and shaven Tanganyikan; and the facial disfigurements of the Gombe and Bakumus women.*

writing of their own when the white men came, except some tribes who had been influenced by the Mohammedan civilization in the north and west. The typical Africans express their feelings most easily in dances, either in war dances or dances of joy. Many of these dances are given nowadays as shows for the whites and may create amusement; but every gesture had significance in days gone by, since they took the place of ritual among white people.

Steps Towards Civilization

All over Africa today are dotted Christian missionary schools. In many parts the only education the natives get is from these missions. Not a few of the white governments and some of the native governments, however, have built and are building schools for the natives.

Educating Africa is slow work. In some parts educated Negroes dressed in European clothes are working as doctors among their own people; and a few miles away other Negroes dressed in paint and feathers are working as witch doctors for a savage tribe. In the same land are Negroes working as lawyers and statesmen, while others are still cannibals.

The recent history of the town of Kano in Nigeria illustrates the strides which Africa is making. For ages Kano, like most native towns, was a mass of dirty mud houses and tiny streets that twisted like a maze. It was impossible to build drains in such a town, and it was easy for robbers to escape down scores of narrow side streets. Kano lies in the midst of a land inhabited almost entirely by black people; but it is the world's best place for the growth of the cacao tree; and when the natives began the cocoa trade with the white men, the people of Kano called in European architects to build proper straight streets in the town.

They pulled down hundreds of

Fig. 4. *Bird's-eye view of the Kaffir kraals at Mochudi, Bechuanaland Protectorate, with a sitting of the Kgotia (native court) in progress. The court is attended by headmen from most parts of the Protectorate and is empowered to settle divorce actions and other cases brought by the natives.*

rickety native houses, made wide streets, erected fine concrete buildings, laid down a drainage system; so that a visitor to this purely native city today might think he was in some place in Europe or America (though the style of architecture is African) and the only surprise would be at so rarely seeing a white face.

Nigeria as a whole may stand well for the future of Africa. It used to be called "the white man's grave," being a land of fevers and sickness (like the dreaded sleeping sickness carried by the tsetse fly). It is still unhealthy for the white man, except here and there along the coast, as can be seen from the population figures: more than twenty million natives to less than four thousand Europeans. The natives, born and bred here for perhaps thousands of centuries, have developed natural immunity to many local diseases against which the white man's drugs and other artificial protectives are not always certain defences.

Three-quarters of Nigeria and the Gold Coast is covered with untamed jungle; yet the natives produce nearly half the world's supply of cocoa. Although the ownership of the product, and the shipping and selling of the cacao, are vested in a few large white firms, the actual productive labour, its control and organization, is almost entirely a black man's business (see Fig. 5).

From thousands of native plantations, through tracks in the forest and the jungle, the cacao is carried to the stations on the white man's roads and railways. The effect upon the black man's life of this international trade is prodigious. It is not merely that gramophones and wireless sets play in mud huts in the forest, or that naked black boys ride along elephant tracks on bicycles; or even that the great town of Kano with its 80,000 native inhabitants is almost wholly European in its aspect, its streets filled with large lorries and buses, and set with cinemas and shops; but that the natives of Nigeria and the Gold Coast, as a whole, buy more goods from Britain each year than do the citizens of the United States of America: such a fact establishes the relations between white men and black in Africa today.

Fig. 5. *Cacao trees in the Gold Coast, with some of the large pods which have been cut from the trees shown in the foreground. It is these pods which contain the famous and invaluable cocoa beans.*

South African Races

This harmony of international trade, penetrating the jungle fastnesses of Nigeria and the Gold Coast, is not found in parts of Africa that are more fully developed, and where proportions between black and white are more even. In the Union of South Africa, for example, the proportion is about two million white to nine and a half million coloured people.

In South Africa neither the black

population nor the white is homogeneous. The native people belong to a great variety of tribes and types, chiefly Bantu and Hottentot; and there are numerous Indians and some other Asiatic traders. The whites consist of the descendants of the early Dutch settlers, the Boers, who form more than half (58 per cent) and speak Afrikaans, a variant of Dutch. Many of these Afrikanders do not speak English, and few of the English-speaking whites can talk Afrikaans.

Here in South Africa is one of the world's centres of racial stress, although, owing to the fact of union and good government, the problems of the races are well on the way to solution (we must continue to use the word races for peoples so clearly differentiated). Many whites are in favour of educating the blacks and advancing them economically; others fear the effects of black competition upon white standards of living. So far, it has been the low standard of living of the coloured men which has proved the greatest burden to the whites; for so many of the less successful white men have found it difficult to get work because the unskilled labour is given to cheaper black workers.

Colour Problem in Africa

This colour problem troubles people throughout Africa. It is necessary to understand that there is little or no racial antagonism between whites and coloured peoples; but that the problems are purely economic, arising from the lower standard of living of the coloured man which enables him to be hired more cheaply, since he is generally content with less. The white man, it must be remembered, has been born into a rich and complex culture: his needs are greater than the simpler-living native. Would it be wise to try to develop the black man's needs, to educate him as fully as the white man, to raise him economically nearer to the white man's level?

It is difficult to answer this question, because the question itself is one of the prime, insistent facts about modern Africa. The fact is, of course, that the question is answering itself slowly, and the black peoples of Africa are advancing with the aid of modern means of communication. It is significant that since 1938 over two hundred native trade unions have been formed in Britain's African colonial possessions: this is the first time that the natives have found political and economic expression of their aspirations.

The ideal of Africa was well expressed by a great black man, Dr. Kwegyir Aggrey, of the Fanti tribe of Negroes, who likened black and white in Africa to the notes of the piano, saying that as both black notes and white are needed for harmony, so black and white men working together for mutual benefit are needed for the true civilization of Africa. This ideal will be reached only when the black peoples are developed economically and culturally to their highest possible level (which may not in the end be so high as that of the whites, but which is probably much higher than most of the black people have yet attained).

The notion that black people may make white people poor, or that white people must keep black people poor, fails to take into account the basic resources of Africa, which, when fully developed, can offer incomparably more

than all that has so far been produced. That is saying a great deal, when one considers that today, at Johannesburg in the Transvaal, black miners each year dig up half the gold produced in the world, about £40 million worth, and that Cape Province and the Transvaal produce more diamonds than any other land, about £10 million worth annually—and these glittering substances are but the luxuries of Africa's abundant soil.

How great are the resources of Africa! And so much of her resources is as yet untapped, from the untouched ores in Abyssinia and the Atlas Mountains of the north and the jungle mountains of the east, to vast tracts of jungle which could be cleared and agriculturally employed by the native peoples.

Two brief pictures must suffice to illustrate development in parts of Africa not yet mentioned.

Development of Morocco

Morocco, in the far north-west, is a land about the size of Spain. It is cut from the dead Sahara by the massive, snow-clad Atlas Mountains, and is a fairly fertile, equable region. Until the last thirty years or so, Morocco had been isolated from Europe for centuries, chiefly owing to enmity between Mohammedans and Christians. The peoples of Morocco lived as they had done since the time of Mohammed, untouched by Western ways.

Subdued by the French, under whose protection they now enjoy a semi-independence, Western ways have even yet but barely penetrated. The French conqueror and first French ruler of Morocco was the famous Marshal Lyautey, perhaps the greatest colonial governor France has ever produced. Lyautey made himself so beloved by the Moroccans that he was the only Christian ever to be allowed inside the forbidden precincts of the mosques, which are always forbidden to non-Moslems. When Lyautey lay dying, prayers for his recovery were said in the mosques, surely the greatest tribute ever offered by men of one religion and one race to a man of another.

The result of Lyautey's work is seen today in the great native cities of Morocco, which, like the medieval towns and cities of Europe, are surrounded by castle walls, sometimes many miles in length, and reached through massive, easily-guarded gateways in the walls. Inside these walls the life of the native cities carries on today as it did a thousand years ago: the streets narrow and winding, characteristically covered in by trellis-work to keep out the burning African sun from the shops, which are mere cupboards or caves in the street walls. Rarely is a European face to be seen in these native streets. Outside the walls, a mile or so away—never less than a quarter of a mile—the French have built their new European towns, in which European life and trade flourish, and through which the land is being developed.

Here are two distinct races, living differently yet respecting their differences, benefiting from one another only to the extent which they desire. It is to be noted that in every city of Morocco—and some cities are immense, such as Marrakesh, the ancient capital, with a population of 250,000—there is always to be found a distinct Jewish quarter: in some of which the Jews are known to have

lived since the time of the dispersal from Palestine.

The natives of Morocco are almost all of the Berber race, the ancient natives who were there before Mohammed; but in the cities and towns and on the coast, they live like Arabs and are Mohammedans, while the peasants of the countryside live entirely differently, being pagans who cannot read or write. To take one difference: the Mohammedan Berber women never appear in public without the face tightly veiled, whereas the pagan Berber women do not cover their faces, but appear as freely as European women.

Life in Modern Egypt

Then for our second and last picture let us go to the other side of North Africa, to the land of modern Egypt, where there is little segregation of races and where the land is more fully developed. Egypt is, of course, an independent kingdom; and its contrasts are first and foremost the contrasts of Nature.

Egypt is a mighty oasis in the Sahara Desert, 600 miles long, never more than twenty miles wide, made by the great River Nile. From an aeroplane one can see two hard wavy lines where the desert ends, and between them the green valley of Egypt. On the ground there are places where it is possible to stand with one foot on the dry dead desert sand, and the other on moist living soil.

Egypt used to be dependent on the annual flooding of the Nile for the watering of its fields, made fertile by the mud brought down by the river from the highlands of Abyssinia and the tropical regions of Kenya, Uganda and Tanganyika. The most important single act in recent Egyptian history was the construction by British engineers of the Aswan Dam in 1903.

At Aswan, where the Nile leaps down a cataract and Egypt proper begins, the engineers flung a vast concrete barrage to regulate the flow of the stream and make Egypt independent of the annual floods. By means of huge reservoirs filled at flood time, and a vast network of irrigation channels, the whole economy of Egypt and the life of the people have been changed.

Twelve hundred square miles of desert are now made to yield harvests. At one point, Kom Ombo, for instance, which had been throughout history a wilderness of stones and jackals, forty villages now stand in a green land and 50,000 men work amid sugar canes and bananas, wheat and vegetables. The controllers of Egypt's economy are now the hydrological experts in their stations along the Nile! The great river has been conquered by science.

Yet many of the fellahin, those peasant descendants of the Ancient Egyptians, do not benefit from these modern developments. The growth and export of cotton—Egyptian cotton is long and silky and is the finest in the world—is in the hands of various magnates, many of them Egyptians. The distribution of wealth in the land still leaves the fellahin to their mud-hovels, their ignorance, their poverty and their hard work. It is a human contrast to see, beside some great modern power station, supplying electricity to Cairo or some other city or town, the patient copper-coloured fellah working his *shaduf*, a simple pole with a weight at one end and a bucket at the other,

laboriously raising water for his crops (see Fig. 6). The *shaduf* dates from the time of the Pharaohs.

Beyond the Nile to the east, on the confines of Egypt, where Africa comes up to Asia, lies one of the great highways of world-trade, one of those focal-points where men of all nations are brought together and commerce of every kind can be seen.

On the Suez Canal one can see ships filled with tea and cotton from India, with rice and silk from Burma and China, with oil from Persia, with rubber from Malaya; ships passing between the ports of East Africa and Europe; liners going to and from Hong Kong, Yokohama, Sydney, London, Liverpool, Hamburg; ships on their way between America and India; ships going from Amsterdam and Rotterdam to Java and Borneo.

A day or two beside the Suez Canal would convince anyone of the vital reality of world trade through which the continents are bound together.

It will be interesting to follow for a moment one thread in this vast warp and woof of world trade; and in view of the previously mentioned importance of jute in the international relations of the United States, let us return to the subject. Jute, in any case, aptly illustrates the common ignorance of those vital materials which link up the homes and lives of peoples separated by the world's oceans.

Jute is a commodity few of us see in its raw form or know anything about, yet it enters into our daily lives as fully as bread or meat. It is used in the making of carpets and linoleums, string and twine, bags and sacks, to say nothing of many materials such as coat linings.

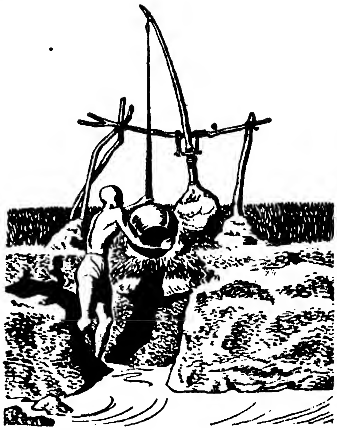


Fig. 6. *Native farmer using a shaduf to raise water from the Nile to his fields.*

If the jute sent from India to Dundee via the Suez Canal in any one year were stretched out straight, it would reach from the Earth to the Moon and back again.

India's Industrial Workers

Calcutta is the second city of the British Empire, with nearly two and a half million inhabitants, only a few thousands of whom are Europeans. Dundee is the chief jute-manufacturing town in the world. All the jute used in Dundee comes through the port of Calcutta. Along the banks of the Hooghly River at Calcutta are more than sixty great jute mills, in which are sixty thousand looms and more than a million spindles.

The jute mills of Calcutta, and the wide jute fields (see Fig. 7) that spread for hundreds of miles through Bengal, together with the work of transport by river and overland, employ upwards of two million Indian workpeople. Men

are employed mostly in the mills (Calcutta has a population of two men to every woman), women mostly in the fields.

Picture the pattern of life laid down for these millions of workers by the world's daily need of string and sacking and linoleum.

Calcutta is also the shipping port for nearly half the world's supply of tea. The greatest tea-growing area in the world lies to the north of Calcutta, in Assam. The work on the tea plantations is largely undertaken by women and girls (see Fig. 8), who can be counted in thousands as they pluck the leaves from the plants and carry them in baskets to the drying grounds and stores to be weighed and sorted.

India's two great seaports, Calcutta in the east and Bombay in the west, are two vast exceptions to the almost universal rule that India's population is a peasant population. Despite the size of Calcutta and Bombay and a few other cities (Bombay has a population of nearly one and a half millions, Madras and Hyderabad of about three-quarters of a million each), the city-dwellers of India form but a fraction of the total population of about three hundred and eighty-nine millions. India has about three times the population of the United States of America, although little more than half the area of that country (India, 1,576,000 sq. miles; United States, 3,026,789 sq. miles).

If one stands upon Malabar Hill, above Bombay, one looks down on

Fig. 7. *Natives cutting jute in the jute fields which extend over hundreds of miles in Bengal. Note the sickle used for the purpose.*

Fig. 8. *Typical tea plantation in Assam, India, showing native women and one of their children picking the tea leaves.*

the greatest cotton-spinning and weaving centre in Asia, beneath whose roofs over a quarter of a million Indians work in more than eighty great cotton mills.

India's Peasant Workers

But the typical scene in India is the rural area—which means mile after mile of lean brown bodies toiling in the fields from dawn to dusk, with no machines to help them, every job of work having to be done by hand (or foot) sometimes with the slow help of cattle or elephants.

It takes an Indian peasant perhaps six weeks to do what a Western farmer can do in one day. It takes forty days of one Indian peasant's labour to raise an acre of wheat. On a modernized farm in the United States, less than one day is needed for the same work.

The greatest agricultural area in India, one of the greatest agricultural areas in the world, is the great Plain of Hindustan, which is a thousand miles long, through the centre of which rolls the broad shining stream of the Ganges. Here are thousands of villages surrounded by hundreds of thousands of fields in which grow wheat, barley, rice, potatoes and other crops.

There are said to be at least seven hundred thousand villages in India—usually these are clusters of huts mostly roughly made of mud and bamboo sticks. The best type of village is probably found bordering the tea and cotton and jute estates, or the rice fields; the less prosperous and more common type of village being largely self-supporting, often remote from civilization, hard by some tract of jungle.

In many areas, particularly in the Plain of Hindustan, a system of dams, reservoirs and canals has largely defeated the age-old fear of drought; but enormous areas would seem still to be dependent on the

caprice of weather and are largely cut off from the outer world.

In general, it is important to note that the greater number of Indian villagers are poorer than anybody else on Earth. Those employed by others as workers in the fields rarely earn more than fourpence a day. The average earnings of India's agricultural labourers is a little less than that, but in considering all such facts, it must be remembered that fourpence in India will buy a great deal more than fourpence in Britain or than ten cents in America. Comparisons in standards of living are always vitiated by local factors which statisticians ignore.

Health and Education

If it is difficult, or impossible, to compare the wealth of natives whose standards of living vary, no such difficulty arises in comparing the health of the nations; though this is not the place to do so. These notes upon India, however, would not be complete without some mention of the physical backwardness of its races and the prevalence of disease. It will be enough to mention that of India's three hundred and eighty-nine million inhabitants, no less than one hundred and fifty million are affected with hookworm and a hundred million with malaria. These are debilitating diseases which considerably reduce the capacity for work and enjoyment of life. One and a half million in India are totally blind. Much of this sickness is preventable, and may be put down to ignorance of hygiene on the one hand and to general dirt and poverty on the other.

The state of general education is deplorable. Out of every hundred men in India there are not thirteen who can write a letter to a friend. Only six in every thousand Indian women can read and write. There are thousands of villages in India where not one man or woman can read and write. There are thousands of villages without a school.

Traditions and Religions

Our sudden jump from Africa to India must not blind us to the total difference between Africans in general and the average Indian. We have seen that Africans are people for the most part who have no history. The Indians are soaked with the history and traditions of their past. If the majority of Indians are ignorant and poor, their lives are richly filled with customs that date back beyond the Christian era and dictate their manners and activities.

The complex religions of India absorb much of the attention of the people; but it is necessary to mention only one or two salient instances of the tyranny of the past over modern Indian peoples. For instance, the caste system is one of the most powerful traditions of Hindu society, and originated in prehistoric times when the original conquerors of India came down from the uplands of Persia and found living in the lowlands people with darker skins than themselves. No lighter-skinned Hindu was allowed to marry or have social intercourse with the darker-skinned natives. This colour bar eventually led the conquerors to introduce class bars within themselves (no doubt some disregarded the bar and a class of half-castes grew up necessitating further rules of segregation).

In the end there came to be four distinct classes of Hindus:—

(1) The Brahmins (priestly class).
(2) The Kshatriyas (warrior class).

(3) The Vaishyas (merchant and farmer class).
(4) The Sudras (servants and slaves).

A man was not allowed to marry outside his class or caste; certain customs and manners were to dictate all dealings between the castes; while the original conquered people were considered outside all castes, or *outcaste*.

The idea has been infinitely developed today, so that the whole of Hindu society is nowadays split up into different castes; many castes being the castes of certain trades and occupations. Thus Hindu society is very restricted and rigid. In fact, there has never been in the history of the world a social system better devised for keeping men and women on separate social levels.

The caste system applies only to the Hindus, of whom there are about two hundred and sixty millions in India. The Hindu faith gives religious sanction to these social divisions; so powerful is this religion socially that if a high-caste Hindu stands even in the shadow thrown by an outcaste (or Untouchable) he must hasten home and perform ceremonies of purification. In practice there is much hypocrisy and overlooking of the distinctions, but publicly they are everywhere rigidly observed.

In Travancore the evil of untouchability is particularly strong, the high-caste Hindus exercising in full their social tyranny over the poor and defenceless outcastes. In the whole of India there are certainly upwards of sixty million outcastes or Untouchables—considerably more than the total population of the British Isles. Gandhi and other leaders have been able to do little to break down this social curse which is one of the worst evils affecting the peoples of India.

Religion in India has far more social effect than in the modern Western world. Ninety million Indians are Mohammedans; and the rivalry and bitterness between adherents of the two creeds constitutes perhaps the acutest problem of the peninsula. There is no personal hostility between Hindus and Mohammedans; but their social customs, sacredly held, often conflict and outrage the feelings.

In India's religious mosaic must be mentioned the Sikhs, Jains, Parsees and Buddhists, each of whom hold taboos and sanctions that dictate conduct and make fraternization difficult with the believers of other religions. There are the animists of the jungle, and about six million Christian Indians.

India's Many Peoples

Religion and the caste system within Hinduism are not the only dividers of India, whose people are generally of such mixed origins that more than two hundred distinct languages are spoken, disabling Indians of one district from conversing with the natives of another area. There is as much difference between the people of Peshawar on the North-West Frontier and the people of Madras on the south-east coast, as between the people of Manchester and Genoa, say, or of Boston, Massachusetts, and Quito in Ecuador.

Owing to the great diversity of languages and dialects spoken in India the English language is often the only means of communication between Indians coming from different parts. In the same way the impartiality of British judges and governors has often been the only

way of settling religious and other disputes.

The infinite divisions of men in India are the result of successive waves of invasion and immigration in the past, as a result of which we find large blocks of people representing each of the main divisions of mankind accounted for in Fig. 2, on pages 168-169. Some typical Indian types are illustrated in Fig. 9.

In the south, along the Malabar and Coromandel coasts and throughout the Deccan, the dark Dravidian peoples predominate; their ancestry lies with the black-skinned races. In a great band through Central and Northern India, in Hindustan, are the lighter-coloured Hindu peoples who belong to a branch of the Indo-Aryan white-skinned races, allied to such seemingly different men as the Celts and Teutons and even the Polynesians (the New Zealand Maoris are cousins both to the Hindus and the British peoples). In wide bands and pools in the north and the centre live those descendants of the Mongols who belong to the yellow-skinned groups, cousins to the Chinese and American-Indians.

To trace in true detail the racial connexions of India we should need to draw a full map of all that is known of human relationships throughout the world. India, standing between the Far East and the Middle East and Europe, has always been a meeting place of nations and armies, trade and war bringing cultures and blood to her shores from every clime. Hence the divisions, the difficult problems of consolidation. Hence, also, the poverty and backwardness, caused in large measure by the lack of cohesion among her assorted children.

Yet the picture of India, with dazzling wealth and abject poverty, with ancient wisdom and abysmal ignorance side by side, is not so hopeless and confusing as a superficial glance might lead one to believe; because her soil is immensely fertile, and soil is the true source of wealth all over the world. Indian peasants who count their wealth in cows have sometimes proved themselves wiser and richer than American millionaires whose wealth is invested in industrial enterprises. The great slump between the two world wars caused many American millionaires to commit suicide, while millions of Indian peasants continued to tend their cattle and crops untouched by the instability of finance.

Sources of Wealth

Real capital is invested in the soil and its crops, in the forests and mountain ores that yield their value to mankind. Real power derives from sunshine and atmospheric oxygen, from flowing water and the natural sources of energy. Thomas Edison was never wiser than when he answered the query: "What is the greatest invention?" by saying: "A blade of grass!" We have machines that can do in an hour the work of a thousand men, machines which can do what no man can do, machines in which we can fly in the air and travel under the sea; but only a blade of grass can convert the inorganic matters of the Earth into food which is fit for human consumption.

A peasant with a smallholding, if he understands the treatment of the soil, and delivers himself of hard work to cultivate his plot, possesses an inexhaustible source of income. To illustrate this, let us embark on a bold contrast, and

Fig. 9. *Eight people living in different parts of India, showing some of the remarkable variations of facial characteristics. Through successive waves of invasion and immigration in the past the population of India includes communities representative of each of the main divisions of the human race.*

compare the history of the soil in the Far East and the Far West. This will involve some slight sketch of the peoples of China and of the North American continent.

Peasant Farmers of China

It is an interesting fact that Chinese peasant farmers, without the aid of machinery or artificial fertilizers, have been known to grow twice the wheat crop per acre that the modern American farmer grows on his mechanized farm—though the Chinaman's feat is at a terrible cost in labour. This is because the Chinese peasant is traditionally wise in the understanding of the soil.

The Chinese peasants are wise in many ways because their civilization is perhaps the oldest in the world. China is not a meeting place of races, and consequently her people are among the most homogeneous on Earth. China has suffered innumerable civil wars, but has rarely been invaded from outside. The life of China has therefore had a continuity and singleness unknown elsewhere. Knowledge has been passed on from generation to generation without a break.

The continuity of Chinese history has made John Chinaman a very conservative being. Progress means little to him. His mind is bound to the past, to his traditions and his ancestors. The family has always been the unit of society in China, and is socially far more important than among Western nations.

Everyday affairs in rural areas throughout China are cared for by the heads of the great families who have lived in each district for generations. These old families supply the local judges and administrators as of hereditary right. This makes for stability in social life, but also for extreme conservatism.

The preservation of the family and its honour provide the code of morals and conduct in all classes of society. Records of the family are kept more faithfully than records of national history, and a child in China will be told the stories of the family heroes long before he hears of the national ones. It is not uncommon for a family to trace its genealogy for a thousand years and more. A certain Dr. Kung traces his descent direct to the great Confucius who lived 2,500 years ago, in the fifth century before Christ.

This conservatism is the salvation of the Chinese peasant farmer, who lives and works with his family on a farm that is usually smaller than the average English farm. Many of these farming families in China have lived on the same farms for countless generations. The fields are their dear family possessions.

No wonder the Good Earth of China is venerated and understood. The young farmer inherits an earth-lore that is almost instinctive, that includes the rotation of crops and the use of natural manures. When we realize that at least three hundred millions in China are peasant farmers, we gain a truer picture of the realities of Chinese life than any other fact can convey.

Conservatism is also in many ways a curse in China. It leaves the Chinese peasant, like the Indian peasant, to a life of unaided toil. Human labour is the one conspicuous thing throughout the two million square miles of China proper. Even in the big cities the help which machines can give is hardly known. It is easier and

Fig. 10. *Street scene in Pekin. Note the rickshaws, and the absence of mechanical vehicles in the street, in this instance.*

cheaper to travel in a rickshaw pulled by a man (see Fig. 10) than to locate and hire a taxi.

Town Life in China

The great mass of the population of China clusters along the gigantic river systems of the Yangtze and the Hoangho. A typical scene in China is one of the trading towns on the gorges of the Yangtze. This town, like many in the steep river valleys, is built on the cliff-tops over the river. There are always clusters of ships along the quays at the base of the cliffs, loading and unloading goods. The streets from the river are made of steps; and every day the steps are a living highway of coolies carrying bulky goods from the river level to the town level high above. No one has thought of a rack-and-pinion railway to aid human muscles, or even provided ropes and pulleys. It is all man labour, human sweat. That is China. It is the wheelbarrow, pushed by hand, that is the universal vehicle in town and country—not the farm-cart.

Despite the earth wisdom of the farmer, the standard of living in China is low; and that we may put down, as in India, largely to the lack of machines. The mineral wealth of the country, and its many natural resources, are largely untapped, because only by the introduction of machinery on a large scale can the extraction and preparation of them be organized. Communications are ill-developed. Railroads are few and far between. There are large districts where even

Fig. 11. *A few types, taken at random, from the many hundreds to be found among the inhabitants of the northern half of the American continent. In New York alone are to be found representatives of every race on Earth. The population of the Canadian province of Quebec is predominantly of French*

descent, while the white population of the independent states on the Isthmus of Panama are direct descendants of Spanish immigrants.

roads are rare. Roads are extending, air routes have been organized, but still whole populations continue to live in virtual isolation in medieval style.

The lack of scientific application has left the country at the mercy of many natural phenomena. The great rivers, source of communication and wealth to the bulk of the people, become at times agents of major disasters. Though dykes and banks have been built along their courses for thousands of miles, these works are mostly local affairs. There is no co-ordinated control of the rivers, so that in the periodic times of exceptional flood, there is always danger of inundation. In the autumn of 1932 there was a typical disaster. The Yangtze Kiang rose in flood and poured over the dykes and banks and flooded an area larger than the whole of England. More than one hundred and thirty thousand people were drowned; an even greater number were left homeless and destitute, and would have died but for the work of the Chinese Government and the help given by the United States Government and British and other charity organizations.

That, then, is one side of the contrast: the Far East of China, with industrious peasant farmers obtaining the utmost from their soil, yet having a poor standard of living and sometimes at the mercy of nature, but assured in normal times of a safe living because of their understanding of the soil.

Life in the United States

For the other side of the picture we turn to the other side of the world, to the United States of America with its vast mixed population (see Fig. 11). One-third of

the United States' hundred and twenty millions are engaged in agriculture. These agricultural workers may also be called peasant farmers, though their farms are much larger than the farms of China, are up to date and mechanized, and the farmers have an altogether better standard of living than John Chinaman. Amongst this mixed population today are Red Indians who bake their bread in beehive ovens (see Fig. 12).

Life in the Mississippi Valley

One-half of the people of the United States live in the great Mississippi Valley. One-half of all the wealth of the nation derives from the soil of this valley. Twenty thousand miles of rivers, draining more than a million square miles of land, gather into the giant Mississippi, one of the Earth's greatest rivers, which the American Indians call the Father of Waters. The Mississippi, with its longest tributary, the Missouri, forms a river over four thousand two hundred miles in length, which is longer than any other river on the globe.

The Mississippi basin includes in its southern sections the great cotton lands where half the world's cotton is grown (see Fig. 13); in its central and northern portions it includes the vast corn belt of the Middle West, a thousand miles of gently rolling land from east to west and from north to south. When white men first came to America this whole region was an ocean of

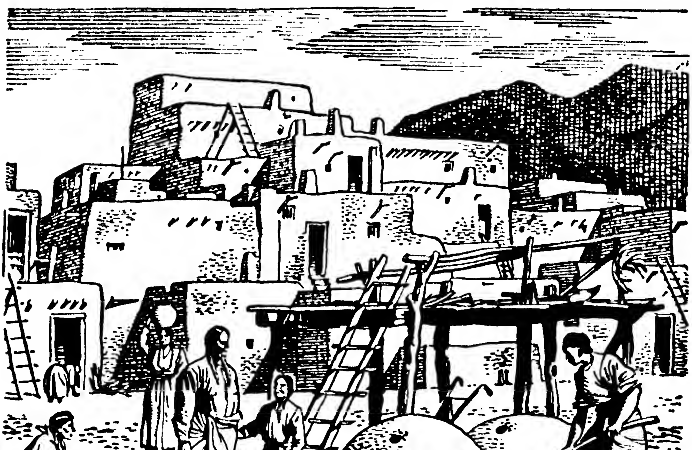


Fig. 12. *Adobe community house in the pueblo of Taos, New Mexico, showing the beehive ovens (foreground) in which the Indians bake their bread. In the past, entry to the house was by ladders---these were pulled up by the Indians when attacked by invading tribes.*

Fig. 13. *Cotton picking on a plantation in the cotton belt, south of the Mississippi basin. Note that the bolls which contain the cotton fibre have burst before being picked.*

grass, home of the wandering herds of shaggy buffalo, and of tribes of hunting Indians. The white invaders slaughtered the buffalo, eventually confined the Indians in their reservations, and set to work to cultivate the ocean of grass.

Impoverishing the Soil

In the latter occupation they had none of the earth lore of the Chinese peasant. They did not seem to realize that even the best farmland consists of not more than a few feet of soil and that soil is a living thing in the sense that it is the home of innumerable living creatures, from visible earthworms to invisible bacteria; that these living creatures have to be fed, and that without them soil becomes sand and farmland deteriorates into desert.

When the white farmers came to the Mississippi Valley they ploughed away the grass and sowed their crops; then harvested, and ploughed again.

They ploughed and harvested, ploughed and harvested, year after year: they turned up the soil, that is to say, and took its crops annually and they gave nothing back to the soil. They ploughed and harvested wholesale for the export market and for the growing cities of the industrial areas of the United States. They robbed the soil of its richness and left it bare and naked in the winter for the rains to wash away and the winds to blow off. Where the lands sloped, fields became cracked with little runnels down which the rainwater ran in streams. These streams in a few years had cut gulleys to the barren bedrock.

At first the farmers were not aware of their danger. Then a farmer here and there saw what

was happening, but knew not what measures to take. By the time knowledge of the danger became widespread it was too late to stave off disaster. Several seasons of poor rain and high winds did the trick: the soil was stripped from hundreds of miles of previously fertile country, leaving the "dust bowl," a region of desert abounding in abandoned farms and many thousands of ruined farmers.

Denuding the Forests

The same thing happened in forest regions of the Mississippi Valley. Up the beautiful Tennessee River, one of the eastern tributaries of the Mississippi, was a land thick with forest and rich with game. Men came to live there as hunters. They lived well by the rod and the rifle, and cut down all the timber they wanted for building, for making their tools and for fuel. They hunted the woodland creatures until there was no more wild life left. They even blasted the fish from the rivers with dynamite. In fact, they robbed the forest as their brothers in the plains robbed the farmland.

And, like the farmers, they found themselves destitute. They tried to farm the land, but much of it was too steep and most of it was too stony. Their homes fell into ruins and they and their families went in rags, with never enough to eat.

Here, indeed, is a supreme lesson about Man's relations with the world in which he lives. How right was Sir Francis Bacon when he said we must obey Nature in order to master her. A tremendous effort has now been made to do this in the United States, and to retrieve the lives and lands of these reckless people. This effort is a challenge to the peoples of the world who still have a low standard of living; and points the way to the future treatment of the Earth by Man.

Before giving a sketch of what has been done, let us note that, like the Yangtze and the Hoangho, the Mississippi and many of its tributaries are subject to dangerous periodic floods. Thousands of miles of banks and levees have been built along the Mississippi, but so far the threat of inundation has not been removed, except on one tributary.

The floods are of colossal dimensions. In 1927 twenty-eight thousand square miles were flooded. The homes of three-quarters of a million people were destroyed. Ten years later more than a million people lost their homes and five hundred were drowned. In 1943 a hundred thousand people lost their homes. The river rose and brought death and destruction in 1944 and 1945. Every year brings the same threat—except on the Tennessee River.

Life in the Tennessee Valley

The Tennessee River has been taken in hand by Man's conquering mind. In 1933 President Roosevelt announced a plan for the control and development of the whole Tennessee River, under the Tennessee Valley Authority. Twenty-seven dams were built, to control the river; but the simple control of the river was not the extent of the plan.

The Tennessee Valley Authority considered the whole of the life of all the people living within the valley, an area as big as England and Scotland, in which four million people dwelt. The plan worked out how the river could be kept from flooding; how its power could be harnessed to the uses of the people;

how it could electrify the countryside; how the exhausted soil could be stopped from washing away; how it could be restored to fertility; how the forests could be replanted; how the hills could be opened to yield minerals never before touched. The plan set out to provide the ruined and backward people with new roads, new river bridges, new railways, new homes, new schools —in fact, a new life and new hope.

Today, a passenger in an aeroplane flying over the Tennessee Valley sees an exciting and moving picture. First the great river itself is held by the grey bulk of the dams, beside which are shining sheets of water where new lakes hold the floods (one town had to be moved bodily from what is now the bed of a lake: it was a quiet, not very prosperous market town; now it is a busy river port). The river is deep blue, no longer murky with soil washed from the land.

The hills that were a devastation of denuded forests are alive with waving crops, the lines of field terraces following the contours, the soil held in by embankments and enriched by artificial manures; with here and there wide plantations of young trees replacing those so ruthlessly cut down. There are new mines, yielding new riches, new roads filled with traffic, new railway lines. Across the valley runs a chain of girder towers transmitting light and power.

From being the poorest and most ignorant "hill billies" in the United States the population has become a beacon-light of progress; for what has been done in the Tennessee Valley can and will be done for the good of mankind in the other great river valleys of the Earth.

There can never again be destructive floods in the Tennessee Valley. The river is too strongly held. There are still floods in the Mississippi, as there are in the Yangtze and the Hoangho and in many other vast river valleys. Even the Nile with its great Aswan Dam has not been conquered as the Tennessee has been. The engineers of the Tennessee Valley can prevent mosquitoes breeding by raising the level of the water in the reservoirs at certain times to drown the mosquito larvæ; in the Nile Valley one of the evils of the Aswan Dam is that mosquitoes breed there, though never before have they bred in Egypt.

Who can doubt that the river systems of all the world will one day be brought under as complete control as the Tennessee?

Throughout the devastated dust bowl of the Mississippi Valley tremendous efforts are successfully retrieving the damage of reckless farming. Wide and deep belts of trees are being planted. Brushwood embankments are being built across thousands of gulleys to prevent further drainage of the good soil. Millions of tons of fertilizers are being showered on the land in a national effort to restore prosperity. Life is slowly returning to great tracts of land, though there are still districts which have to be abandoned for the time being.

Cities of the United States

Thus, through trial and error, Man founds his kingdom on the Earth. In the United States of America, as elsewhere, the signal of Man's triumph is most evident in his cities. This is most clearly seen in the United States in the City of Chicago, a city strategically placed in the heart of the North

American continent. With a population of three and a half millions, Chicago is growing more quickly than any other city in the land. The people of Chicago say that in a few years their city will be the largest in the world.

Consider the causes of Chicago's growth: south of it, to east and west, stretches the corn belt (which is not by any means all turned into the dust bowl, but remains one of the great wheat-producing areas of the world). Chicago is the chief grain market of the world. Chicago is the market to which the cattle of the western ranches come, so that it is the most important meat market in the world. Right outside Chicago are some of the largest and richest coal mines and iron mines in the land. There are oil-fields near Chicago, which stands on the south shore of Lake Michigan, so that the water transport of the Great Lakes has made it an ocean port, the only ocean port that is in the heart of one of the great continents. The series of deep river locks on the St. Lawrence River now enables large merchant ships and ocean liners from Europe to steam across the Lakes to berth at Chicago.

The United States of America is pre-eminently the nation of great cities. It has no less than five cities with a population of more than a million; New York, seven and a half millions; Chicago, three and a half millions; Philadelphia, two millions; Detroit and Los Angeles, a million and a half.

Growth of World's Cities

Nothing is more striking in the world of Man today than the continued growth of great cities. Even in predominantly agricultural countries the vast city centres continue to grow. In Australia, for instance, which has a total population of about seven millions, there are two cities with a population of over a million, Sydney and Melbourne. We have seen how overwhelmingly the peasants predominate in China, yet China already rivals the United States in the matter of big cities: Shanghai has nearly three and a half millions; Peiping (Pekin), Canton and Tientsin well over one million each. China cannot be considered as an industrially developed land; but Japan is highly so, and it is not surprising to find that Tokyo has six millions, Osaka three millions, Nagoya and Kista one million each, while Kobe and Yokohama are not far below one million each.

A few years ago Los Angeles was fourteen miles from the Pacific coast of California. In the last decade it has spread over seven of those miles, and during the next it may well have a sea-front on the ocean and double its present population.

In the past, the size of cities was kept down because of slow and poor transport, and by the incidence of disease. Today, through mechanical communication, theoretically an unlimited number of people could be supplied with daily necessities and luxuries in one centre of concentration. What this means in transport may be gathered from the fact that in a big Western city between five and six tons of goods have to be carried into the city for each citizen each year! It is only through the development of modern sanitation, administered by enlightened public health authorities, and through the widespread knowledge of hygiene, that men can live together in such staggering numbers

as we find in modern cities, without fear of epidemics.

The battle against disease, however, is fought fiercely in many big cities. No town can be really healthy with more than fifty people to the acre: in parts of London there are 365 people to the acre, in parts of New York 349, in parts of Edinburgh, Dundee and Glasgow more than 670. Many Eastern cities can show even greater crowding. Although epidemics can sometimes be held in check, the result of overcrowding is stunted growth and health below normal.

Racial Mixtures in Cities

A wonderful aspect of most great cities is that in them dwell a greater variety of races and tongues than are to be found in any similar rural area. This is particularly true of cities like New York where, in districts of their own, live men of every race and tongue on Earth. There are districts called Little Italy, Little Slovakia, Little Lithuania and so on, because only Italians, Slovakians, Lithuanians live in those districts. There are groups of streets in which you hear predominantly German spoken, districts lived in almost exclusively by Poles, Greeks, Russians, Czechs, Armenians, Yugoslavs, and many other types. There are more Irish people than there are in Dublin. There are more Jews than there were in Jerusalem in the days of King Solomon's glory. There are more Italians than there are in Rome. The district of Harlem is like a big Negro city in the heart of New York. The Chinese quarter round about Chatham Square resembles some city of the East.

It is perhaps to be expected that so great a mixture of the peoples of the world is to be found in almost every city of the United States, since the nation was founded by immigrants. Yet most great cities throughout the globe show a surprisingly mixed population. The proportion of foreign-born citizens in London is typical. No less than two hundred thousand Londoners are of foreign extraction, including thirty thousand Russians and nearly as many Poles.

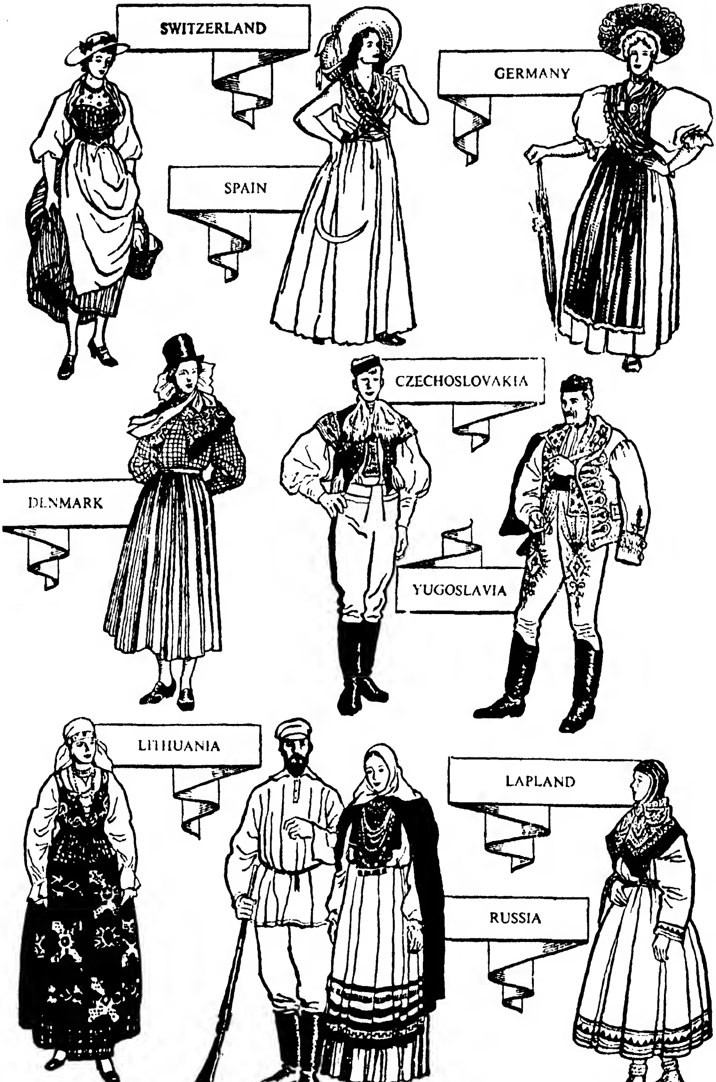
London is, of course, the greatest town agglomeration of all, with a population of approximately eight millions for the Greater London area. In London live more people than in the whole of Canada. Every day more people in London travel on the London Transport system—Underground (tube railway), omnibus, trolleybus, and tram—than are to be found living in all Australia.

Industrial Britain

Britain is the most highly industrialized nation. Today eighty-seven out of every hundred people in Britain live and work in cities. The growth of industrialism in the world generally is best illustrated by the fact that Britain, the oldest industrial land, had a greater rural population than town population little more than a hundred years ago. By 1850 country folk and townsfolk were on a fifty-fifty basis. Sixty years after that, three-quarters of the people lived in towns.

The cities of the world are hives of industry and production, but above all they are the great consumer centres, drawing their life from the millions of miles of agricultural areas. The greatest concentration of blast furnaces and factories has a green background in the open fields. Behind every industrial worker labours the farm

Fig. 14. *Some of the national costumes of Europe. These traditional dresses have been worn by the peasant populations of Europe, without any material*



change of design, for many hundreds of years. Some of the more elaborate dresses are, of course, worn only on festive occasions, such as at marriages.

worker upon whose skill and energy the town dweller ultimately depends.

It has been estimated that the average day's labour of one man on a wheat farm produces enough bread to feed that man for a year. On this basis, a man who works three hundred days in the year on such a farm produces enough bread to feed three hundred men for a year.

The growth of great cities is said to be due to the greater amenities of city life. In some respects this is true, but in others, especially that of occupation, farm labour is far more varied than factory work, or than office work for that matter. The changing seasons call for change of occupation on the farm, added to which life is generally healthier so long as home conditions are good.

City Life in Europe

In stable countrysides which bear some rational relationship to the proportion of city dwellers, the farming communities have developed their own way of life that is totally distinct from the life of cities. This contrast is found strikingly in Europe, of whose population of some four hundred million, more than one hundred and fifty million are peasants. The population of Europe, we may note, is more than three times as large as that of the U.S.A., and roughly equates with that of China or India.

The city dwellers of Europe are not strikingly different from the citizens of London or New York. They speak French in Paris, German in Berlin, Polish in Warsaw, and so on; but they say pretty much the same sort of things in their different tongues. The people see many of the same films and plays in the theatres. The ordinary men and women in the street wear the same fashion in suits and shoes and hats as is worn in every modern city upon Earth. The shops follow the same fashion of architecture and lighting, and display many of the same types of goods. The idle tourist may delight to pick out differences, noting that in Madrid men go to bed at midday and the city is in full swing of life at midnight, while Prague, say, or Stockholm, is settling to sleep at midnight, like London and Berlin; that in the heart of Paris men and women sit out in the streets to eat and drink, while in London they sit indoors; but these are superficial differences, and though they might be multiplied delightfully for scores of pages, they do not alter the fundamental similarity of routine and outlook of the average city dweller everywhere.

It is when we come to the country folk that we begin to find real differences in Europe; and here we note the contrasts of nationality and tradition. The peasants of Hungary, Rumania, Poland, Lithuania and the other states of Europe have national costumes (see Fig. 14) and customs that have not materially changed for hundreds of years.

European Peasant Customs

Thus you will find them at certain dates celebrating age-old customs with age-old dances, like the Rumanian national dance called the Hora. In this dance men and women in their national costume stand in a circle holding each other's hands. Then with rhythmical steps, first to left then to right, now backwards now forwards, they dance the traditional steps to the music of some peasant band or a band of

gipsy strolling players, while some bard sings verses whose origin is lost in the mists of antiquity.

Much of the culture on which the great cities pride themselves has grown originally from the traditional peasant culture; and it is but some slight indication of the debt we owe to the peasants to recall that such famous melodies as Liszt's Hungarian Rhapsody No. 1 is but a fully-orchestrated version of a traditional melody known among the Hungarian gipsies; or that the "Song of the Volga Boatmen" is actually a peasant melody from the toilers on the banks of that great river. Poetry, art, literature, as well as music, have all been inspired and enriched from peasant sources.

Many peasant customs are solemn and religious, like the centuries-old Passion Play staged every ten years at Oberammergau in Bavaria. There are several other villages in Europe where equally ancient traditional plays are periodically performed.

Religion in its traditional forms plays a considerable part in the life of many peasant communities, where such picturesque ceremonies as the "Pardons" in Brittany provide a present-day pageant from an old-time Europe which one would think had passed away if the cities only were visited.

There are still countless large districts where the traditional costumes are habitually worn (see Fig. 14), from Greece where the shepherds wear their ancient styles of dress, to the hills of Norway where the everyday life of the peasants is lived in their traditional clothes. Among the best-known of these is the Dutch costume still worn in Volendam, Marken, Walcheren and elsewhere: the variations of the wide baggy trousers and short tight jackets for the men; barrel-shaped dresses and bodices with starched hats for the women; and the well-known clogs for both.

Europe's Mixed Population

And this, perhaps, is the place to remind ourselves again of the mixed quality of the population in every European nation (see Fig. 15). In France, for example, the Breton peasants of Brittany, the Basques of Gascony, the Provençals, the men of Picardy, and many more, each have their manners and customs, their special cultures, and memories of an ancient time before France was a single nation. We speak of France, Germany, Spain, Italy, Hungary, and so on, treating each nation as homogeneous, whereas racial strains, languages, customs, beliefs, traditions, laws and temperaments differ from one department and province of each land to another.

The typical European is the peasant: it may seem paradoxical to speak of the peasant as typical when one recollects the many differences between the peasants. It is, however, only necessary to look along the Danube River in order to see that it is true.

Life in the Danube Lands

From a hedge-hopping aeroplane flying down the valley of the Danube, everywhere the land looks very much alike. The pastures and the crops are the same. Everywhere are fields of maize, in which peasants work with the same kind of tools, with oxen to help them. Costumes differ in Rumania from Bulgaria, in Hungary from Austria, and so on; the patterns of houses and churches change from Yugo-

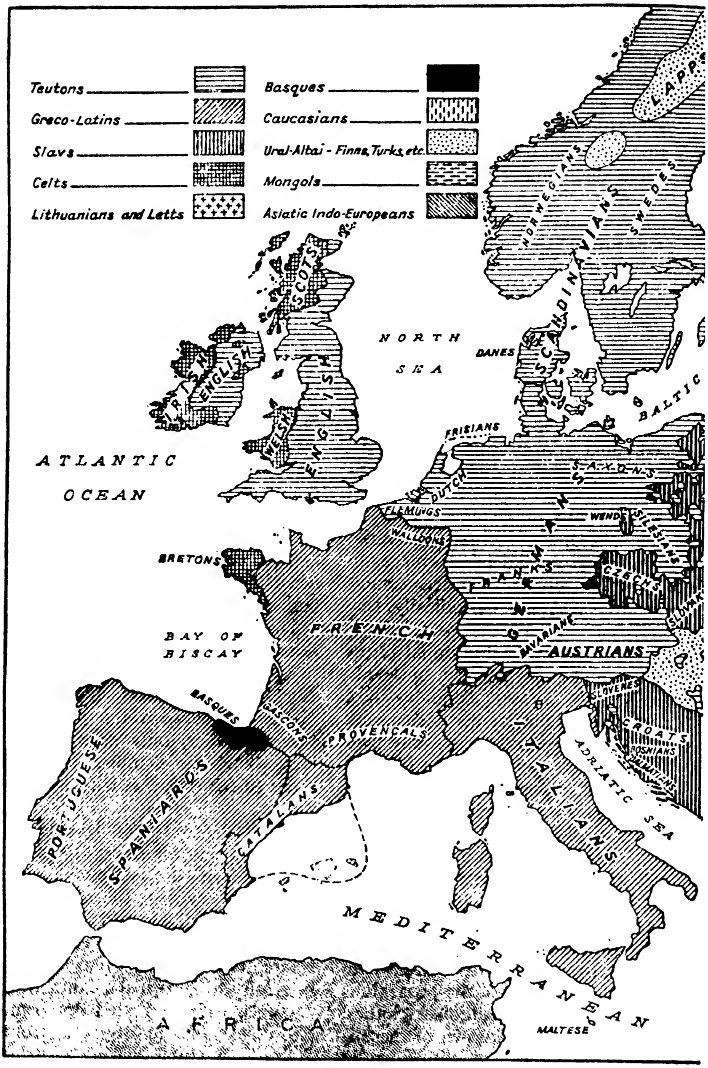
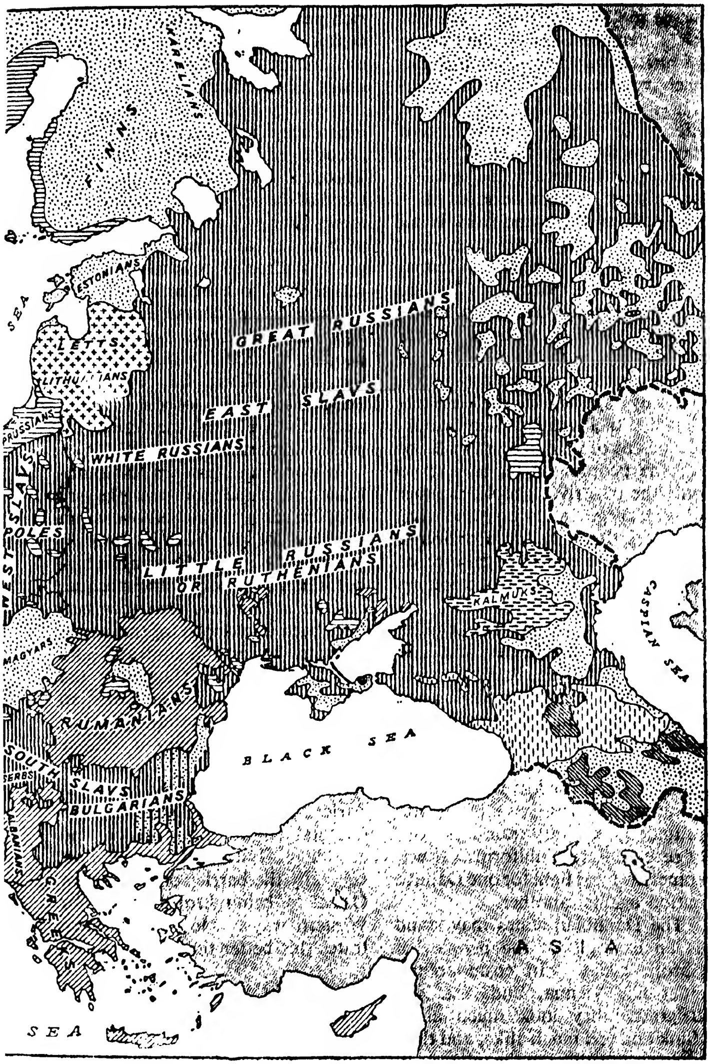


Fig. 15. *Map keyed to show the distribution of the predominant racial types throughout Europe. Superimposed on the map are a few names of the many*



smaller communities with distinctive characteristics or languages, such as those of the English, German, Flemish, Dutch and Scandinavian peoples.

slavia to Czechoslovakia. The only big difference between the peoples of one country and another is that each speaks a different language. The people live the same kind of life, performing the same kind of work on the same kind of soil, all the way up the great winding waterway almost for eight hundred miles. The pattern of life and work is laid down for them in the fields and makes them the same sort of human beings, the true peasants of Europe. Their interests are in common, though too many of them are too little aware of the fact.

The rivers of Europe are natural highways serving all the countries that line their banks. The Danube is a means of world communication for the peoples on its banks; yet only the true river people, the men of the barges and tugs and river steamers that pass from nation to nation in the course of commerce, are as truly at home in one country as in another.

In schools along the Danube, children are taught national histories: in Rumania, Rumanian history; in Bulgaria, Bulgarian history, and so on. Children are taught of battles won against their neighbour nations, and are reminded of grudges owed for lost wars. When a waterman's son grows up, he has to undergo military training in one of seven different uniforms. If war comes, he must fight for one Danube nation against another.

The Danubian states may stand as an example of the peoples of Europe today. In cosmopolitan cities like Vienna, Budapest, and Belgrade, they look much alike, think and feel much alike, and their interests are allied to the interests of the whole world which subsists on international trade. In the wide rich peasant lands, their work and conditions are similar, their interests are identical, even though they differ as to costume and custom; but in city and town alike many differences are perpetuated and encouraged by historical teaching. Through the generally patriotic trend of the several national governments, unity of interest is overlaid with historical divisions, and purpose is directed towards national rather than to European ends.

There are, of course, many deep and real differences between the peoples, particularly between Teutons and Slavs; but the most extreme contrasts of culture and tradition are not the cause of present bitterness.

In pools and patches in South-Eastern Europe, for example, are Moslem communities left over from the days of the Turkish Empire. Particularly in the Balkans are to be found veiled women and mosques and an atmosphere that seems to have been unchanged for thousands of years. No greater contrast could be found than that between the Mohammedan and the Christian communities of Eastern Europe; yet there is an easy tolerance between them.

We have seen already, in North Africa, the persistence of an Oriental culture in Morocco and elsewhere; but in the Near East generally the barrier of the ancient Orient is being broken down by Western ways. No country illustrates this better than Turkey.

The Reform of Turkey

Up to 1922, Turkey was the acknowledged leader of the Moslem world, because her monarch, the Sultan, combined temporal power with the spiritual headship of

Islam. With the abolition of the Sultanate, in 1922, the Mohammedan world no longer had a spiritual head, and Turkey lost her leadership of the Near Eastern nations. She had lost her Empire anyway, finally at the hands of General Allenby (not without aid from T. E. Lawrence and the Arabs), but was rescued from partition by Mustafa Kemal, a man of the people who rose through military and political genius to be supreme in the new Turkish Republic.

There had been nothing in the world before like Mustafa Kemal's reform of Turkey. Here was an ancient and backward land, steeped in Orientalism, untouched by Western progress. In a few short years Mustafa Kemal completely changed the fundamental culture of his country. Whereas the Sultan had been supreme and the divine leader, Mustafa Kemal instituted a secular democracy, calling himself, simply, the First Citizen.

From matters of deeply-rooted religion and politics Mustafa Kemal turned to the clothes and customs of the people, emancipating the women from their veils and harems, causing men to doff turban and flowing robes and don Western attire. Moreover, he achieved the miracle of changing the thought of his people from Orientalism to Occidental culture. He substituted for the old and difficult Arabic script modern Latin lettering. Mustafa Kemal actually went about the country himself like a schoolmaster, teaching with a blackboard those who were to teach the youth of the land.

Communities are normally tenacious of tradition, which makes the cultural revolution of Turkey all the more remarkable. Today the only groups of people who perpetuate the old Oriental Turkey are those in the Balkans who were out of reach of Mustafa Kemal's reforms.

Near Eastern Communities

Here and there throughout the Near East one finds isolated communities which, in like manner, have not changed—many of them far more ancient than the Turks. They provide some dramatic and amusing contrasts. In Syria and Lebanon, in Iraq and Palestine, are many people living much as their ancestors lived in Bible times.

A few miles from Jerusalem one may come across some camp of the old tribe of the Samaritans, their sheep grazing near the wonderful oil pipe-line that runs from the Euphrates Valley to the port of Haifa on the Mediterranean. One sees a little group of brown-faced people in flowing robes journeying slowly with a pair of lumbering oxen harnessed to a jolting wagon; then the air throbs with the heavy purr of the giant air liner on its way from Cairo to Baghdad.

It is not surprising that these contrasts persist in this part of the world, since the eastern seaboard of the Mediterranean has always been a focus of races and cultures, an axis of commerce and conflict, a land alike of religious origins and cultural revolutions. Perhaps the most curious people in the Near East—in some respects the most curious people in the whole world—are the Yezedi who dwell on the borders of Iraq and in the Mosul region.

They are described as a religious sect rather than a tribe; and would seem to be of mixed Persian-Arabic stock. On the average the Yezedi

spend a quarter of their incomes on religion, yet they never pray. They worship trees, especially the mulberry, yet believe in much of the Old Testament, the New Testament and the Koran. They pay religious respect to the Devil (whom they represent as a peacock), yet expect the Second Coming of Christ. They believe in the transmigration of souls and have many tales of Hindu folklore and mythology; but they also recognize Mohammed as a Prophet and have a ceremony in which they worship the Sun.

It would seem that nearly all the religions of the world have passed and re-passed along the highways of Syria and Iraq, and each has left something for the Yezedi to ponder. Yezedi traditions and legends are Mohammedan, Christian (especially Nestorian Christian), Zoroastrian, Kurd, Sabæan, Mesopotamian-Syrian, Persian (Yezd), Hindu, Assyrian, Aboriginal Animistic, with a groundwork of extremely primitive pagan cults.

These astonishing people are in fact a living summary of the religious history of mankind. They could certainly be found nowhere else than in a centre of caravan routes that are as old as civilization. The Near East is, of course, the cradle of religions and cultures. To Mecca and to Jerusalem are drawn thousands of pilgrims every year. Great modern movements, like the Jewish ambition to found a national home in Palestine, have their roots in vivid sentiment and sacred history.

On the coast of Palestine, near Jaffa, stands the only wholly Jewish town in the world, Tel-Aviv. Thirty years ago there was nothing here but wasteland; now there is a modern city of one hundred and thirty thousand, and for many miles around are vineyards, plantations of cotton, orchards of fruit, and wide-spreading community farms, intensely cultivated.

In strong contrast to these progressively-cultivated fields of the new Jewish communities are the roughly-tilled fields of the Arabs, among whom co-operative endeavour in farming is unknown. The Arabs are content to use medieval methods, hand-ploughs and lean horses, on small individual farms that yield but a poor return. Miles of land that might become more fertile is in consequence but half tilled or left wholly to waste.

We are not here concerned with the political problems arising from such distinct communities; but the full cultivation of the Earth's soil, the full development of the world's resources, is an urgent problem at a time when population is everywhere rapidly increasing.

Peoples of the U.S.S.R.

In no nation has cultivation and development been more rapid than in that vast land that lies to the north of so many of the lands we have been considering. The Union of Soviet Socialist Republics, the Soviet Union, stretches from the Far East, a thousand miles east of China, to the borders of Poland, Czechoslovakia and Rumania, an east-to-west distance of more than five thousand miles: it lies athwart the great land mass of Asia, from the Arctic Ocean to India, a north-to-south distance in some places of two thousand miles. All the way from the Black Sea to the Bering Strait belongs to the Union, comprising more than one-seventh of all the land there is in the world.

This vast area is not populated

according to its size. Enormous segments are desert, like much of the northern steppes of Siberia, and the desert of Gobi in Mongolia. The Soviet Union has a population of over a hundred and eighty millions; and these represent about two hundred nationalities, speaking some one hundred and fifty languages and dialects.

Life in European Russia

Three-fourths of these people live in European Russia, west of the Ural Mountains. This region has for long been one of the world's great centres of agriculture, particularly the black-earth region of southern European Russia, including the Ukraine.

Up to 1914, European Russia was known as the granary of Europe. It produced in a single year more than a thousand million bushels of wheat, a thousand million bushels of rye, and almost a thousand million bushels of oats. It is interesting to compare the productivity of the corn belt of the United States with European Russia. In the United States, a thousand million bushels of wheat in one year, without rye or oats, was considered a great achievement; furthermore, the farms of the corn belt were fully mechanized, whilst Russia produced her staggering harvests almost without the aid of machinery. The resources of Russia in fertile soil and man-power must, therefore, become plain.

Out of every hundred Russian people, eighty are peasant-farmers and agriculturists today; the proportion was even larger in Tsarist days. This follows from the fact that Russia has more rich soil on level land than any other country in the world. With the exception of the Ural Mountains most of the land is less than a thousand feet above sea-level. There is no other region of the Earth like it.

In European Russia, as well as in the Asiatic territories, one can ride for days, in the stiff, crude ox-carts of the peasants, as upon a level ocean of earth. From village to village one bumps along tracks that pass for roads. Now and then the spire of a church is seen over the horizon. In an hour or two the muddy road leads to another village of log and mud huts. There are some three hundred thousand such villages scattered over the continental plain, varying from hamlets to fair-sized towns, but all looking very much alike.

In these villages, before the Revolution, lived nine-tenths of the Russians, isolated from one another and from the cities, unconnected by railroads, telephones or telegraphs. Since 1917 vast changes have come over the Russian countryside. Though there are still tens of thousands of log-cabin villages, few lack good roads, fewer still have no telephone or telegraph communication, and none are without radio.

The Revolution of 1917 caused the old order to vanish, and a new order was only established with bloodshed. Only with the introduction of the various Five Year Plans was Russian life re-established.

The breaking-up of the great estates in the Revolution had resulted in a chaotic growth of peasant smallholdings that could be made a national asset through amalgamation into collective farms. By 1931, six and a half million peasant households in European Russia had been persuaded to put

their little farms, animals and implements into a common pool. Fences and other barriers between separate plots were destroyed, making vast open fields on which tractors and other farm machinery could operate.

Statistics show that this social revolution and mechanization have resulted in heavier yields than in Tsarist Russia; certainly the life of the peasants has been raised to a new high level.

The collective farm has brought a bigger population and more social life to the countryside. Every big collective farm has its own theatre (with travelling companies of players and their own amateur efforts to fill the bill), cinema and lecture hall, club rooms and library. Some farms produce their own newspaper and engage in many cultural activities. Schools, of course, are to be found now everywhere in Russia. As late as 1920 sixty-three out of every hundred people in all Russia were unable to read or write. The education of this tremendous illiterate peasantry must always be the proudest achievement of the Soviet regime.

Life in Asiatic Russia

It is in Asiatic Russia, east of the Urals, that the greatest agricultural development has taken place, and the greatest development of mineral and other resources. Here was a land more isolated and backward than any other continental area in the world. On the Siberian plateau, between the Caspian and China, men's way of life had changed little since the Middle Ages. Progressive peoples avoided the ignorant Oriental cities of the south, whilst the forbidding interior of Siberia was almost synonymous with exile and penal establishment.

One-fourth of all the Russians live in Asia, about forty millions between Turkestan and Vladivostok. It is in this region that is to be found the greatest variety of languages and nationalities, particularly in the south in the five republics of the Tadjik, the Turkmen, the Uzbek, the Kazakh and the Kirghiz. Some indication of Soviet developments in this region may be gleaned from the fact that the population here has increased by three millions in ten years, two millions increase in the towns, one million increase in rural districts.

Here are to be found, a few miles apart, some of the oldest cities in the world, and some of the newest. Old towns, like Bokhara with its eighty thousand Mohammedans, look today very much as they did a thousand years ago. We are taken straight back to the Arabian Nights in the narrow, winding, cobbled streets of Bokhara, with their overhanging houses, their elaborate mosques and picturesque gateways, the Oriental crowds in the streets. But the women go unveiled and mingle in public life as much as they do in any Western city. There is modern education in the schools, for girls as well as for boys.

In this ancient land there are modern cities like Stalinabad, a steel-and-concrete town which up to 1925 was an untidy straggling village called Dushambe, which means Monday, because that was the day on which the market was held. Today, its modern streets, big public buildings and rows of villas are surrounded by the well-tilled fields of many collective farms. Stalinabad is now a town of

a hundred thousand Soviet citizens, and is the capital of the Tadjik Soviet Socialist Republic, with its own kremlin in the heart of the town.

Stalinabad is typical of the progress of civilization in the Central Asian Republics of the Soviet Union. The chief single agency of change in these hitherto unchanging regions is modern communications, particularly the railway. The famous Turk-Sib Railway (Turkestan-Siberia), was begun in 1927 and completed in 1930, and gave the first real impulse of life to these forgotten places. This line joins, through Tashkent and Alma Ata, with a branch of the Trans-Siberian line (Moscow-Vladivostok) at Semipalatinsk. New branch and trunk lines are being frequently opened, perhaps the most important recent one being that between Karaganda and Balkash, opened in 1941.

Mongolian Traders

A few years ago the most common sight between the towns in this part of the world was the camel caravan. Such a sight is still common, and is likely to remain so to the northward over the tremendous extent of the Siberian steppes. These lands are crossed by caravan trails which can probably claim to be the oldest roads in the world. A wonderful sight is a Mongol caravan crossing this sparsely-inhabited country. A Mongol never walks if he can help it. He travels everywhere on camel back or mounted on his sturdy pony. The Mongols dress brilliantly in flaming red, yellow and blue. On their feet they wear great boots with pointed turned-up toes and flat soles. They may drive before them enormous droves of sheep, cattle, goats and ponies. Caravans of Chinese traders are met with far inland from the border of China, taking tea, cloth and tobacco to Central Asia, and returning with wool, hides, fur and ponies.

Life in Mongolia has not changed since the dawn of time. Just within the borders of China thousands of Mongols annually make pilgrimage to the shrine and burial place of Jenghiz Khan, the twelfth-century world conqueror, and perform there ceremonies no Westerner has ever seen. But the inevitable spread of the railroad, and extension of air lines, must ultimately break down isolation and bring these peoples into touch with the rest of mankind.

Communications and Civilizations

New towns spring to life, as at the touch of a magic wand, with the coming of the railroad. New ideas come to the people, new ways of life replace old, and new prosperity dawns. The wasteland yields crops. The barren hills open and give of their ores. This has been seen to happen in some hundreds of centres in Central Asia, mostly in the southern and western sectors. All along the eastern slopes of the Urals there is a chain of brand-new cities, tapping the resources of this mountain range, whose previous use was limited to marking the boundary between Europe and Asia.

Mr. H. G. Wells has truly said that the control of communications is the measure of our civilization. It is obvious that development of resources is impossible without swift and sure communications. In the modern world, air transport cannot compete, in the regular carriage of great masses of heavy goods, with land transport. For this reason, good roads often have

greater importance than airways—as witness the vital Burma Road in the history of the Far Eastern war, and the necessity for constructing the Alaska Highway in the American attack upon Japan.

Our interest in means of communication in this article rests upon the revolutionary changes wrought in the homes and daily lives of men by the extension of railway lines. Many vast communities today depend upon the railroad for their standard of life. In the earlier days of the British Empire the western provinces of Canada, the people of British Columbia, refused political union with the eastern provinces, until a railroad was laid across the prairies and over the Rocky Mountains, to link them to their fellow-Canadians in the east.

The necessity for developing the Earth's resources to the full is illustrated by the fact that in less than a century and a half the population of the world has more than trebled. It is impossible to give exact figures for world-population; but the recent reports of the United States Bureau of the Census put it at one thousand nine hundred million. We may safely say the Earth supports nearly two thousand million souls.

Life in Japan

The increase in the world's population is due primarily to modern communications and the mechanization of production. This is nowhere better illustrated than in Japan, where the problems arising from rapid increase and industrialization are seen, as it were, under a microscope, in small compass.

The population of Japan doubled in less than half a century. Only seventy years ago the Japanese people knew as little of Western ways as the old Turkish Empire did. Seventy years ago the Japanese lived in much the same way as Britons lived in the days of the Normans and the Plantagenets. Great lords and barons ruled their own districts, which together covered the Japanese islands. The Japanese soldiers wore medieval armour and among their chief weapons was still the bow and arrow.

The influx of Western ideas came suddenly. There was no Mustafa Kemal to introduce democratic ideas; instead there were the feudal barons of Japan with their traditionally strong and hidebound ideas of feudalism. Through industrialism the entire economy of the land was revolutionized; but the vast new industrial society remained in the hands of the few feudal lords.

In Britain and the Western world the Industrial Revolution took a hundred and fifty years to mature, indeed the best part of two centuries. In that time democratic ideas had time to become established, social services were developed, particularly under the influence of the French and American revolutions. Western people had time to adapt themselves to the new industrial way of life. In Japan the process was rushed through in half a century under the leadership of men with medieval ideas.

Today the Japanese find themselves thoroughly Westernized as to means of production and communication, yet living in the ideology of the Middle Ages. The industrial feudal lords of Japan set up the Mikado as a divinity, to be worshipped far

more thoroughly than ever Britons worshipped their kings when the "divine right of kings" was a living issue in the West.

But consider a few facts to the human background in Japan. The islands of Japan greatly resemble the British Isles, both as regards position and extent. The main island of Japan, Hondo, lies off the continental coast of Asia, as Britain lies off the coast of Europe. Hondo is comparable to Great Britain in its size, being nearly nine hundred miles from north to south, and nearly two hundred miles at its broadest. As late as 1872 the population of Japan was little over thirty millions. At the census of 1923 it was over sixty millions. It is now something like one hundred and five millions.

As in the Near East and Central Asia, Japan is a land of contrasts, of the very old side by side with the very new. In the streets of the towns and the roads of the country-side a great proportion of the people wear modern dress and use modern vehicles; but the one desire of many men after their day's labour is to put on the old national costume, the flowing robes of old Japan, and to recline in the garden under the lanterns hanging from the trees. In the streets factory girls in trousered overalls pass girls in the old-fashioned kimono. Beside the high-powered lorries and automobiles and electric trams run the rickshaws, the ox-carts and a variety of hand barrows.

Some millions dwell in modern concrete villas and work in factories (some with roaring blast furnaces) or in steel-and-concrete office blocks; but millions more in suburbs and small towns and villages still inhabit the bamboo-and-paper dwellings of their ancestors and engage in many traditional handicrafts.

The Japanese are imitative rather than creative. They are naturally vigorous people. The world had peacetime experience of their enterprise, in many spheres. Up to the Second World War, the most remarkable feature of the world's fishing industry was the position held by Japan, which, as regards the quantity of fish supplied, led all others. Until British steam trawlers had girdled the globe in search of catch, and had fished off the shores of Japan, the Japanese had never conceived the idea of steamboats to catch fish. They quickly realized their omission, and built fishing fleets after the British model, with the aid of British engineers and seamen. So quickly did their fleet grow that it soon outnumbered any other national fleet. The result was that a fish retailer in almost any other country could offer a customer, say, two tins of salmon of practically the same size, but one at half the price of the other. The cheaper was the Japanese.

No doubt other instances of Japanese competition will occur to the reader. The cheapness of Japanese products was of course due to the generally lower standard of living among the Japanese compared with Western workmen.

The aboriginal Ainu of Japan are now confined to the northern island of Hokkaido, and racially are among the world's most interesting people. Their communities are now small, and are rapidly dwindling. Like the Japanese, they are of small stature; and they are relics of a very ancient human stock who may once have populated most of northern

Asia (Proto-Nordic). Their culture recalls in many ways that of the Stone Age. They practise the most primitive kind of agriculture; the men are still hunters, though the women have developed beyond the mere collecting stage and grow simple crops. The religion is a form of animism, special veneration being given to the bear.

Such small, obscure communities are not likely to trouble world markets; but they illustrate the ingrained varieties of mankind, and in lesser degrees many communities are so differentiated from one another throughout the world. They cause us to realize that the different wants of different communities make equation of living standards at present an impossibility, although the difficulties may be overcome. At the present time it would seem that only by protection and tariffs, or by bold world controls of exports and exchanges can the varieties of standards of living be prevented from corrupting the world's economy.

Contrasts in Australia and New Zealand

Contrast the conditions of white men in Australia with those of the blackfellows. In wild places in the heart of Australia the aboriginals live as men everywhere lived before civilization began. They hunt the kangaroos and wallabies with boomerangs and spears. They set simple traps for the emus. They live largely on frogs, rats, snakes, grubs, the honey of the wild bees and the honey-ants, on stems of plants and roots and seeds. Their homes are rough shelters of sticks. They do not know how to cultivate the soil or store food or keep beasts for use. And the important and worrying thing is that the white men do not seem able to impart the rudiments of European culture to these primitive men.

Yet white men have found how to bring forth from the previously barren soil of Australia vast pastures and crops by tapping the hidden stores of water beneath the soil. In Queensland many thousands of artesian wells have been bored to these underground seas. Because they have known how to use Nature's reservoirs, white men are now able to keep many millions of cattle and sheep on the great plains of Australia and to turn millions of acres into wheat fields. Only a few hundreds of miles from the rude shelters of the aborigines rise the tremendous cities of Melbourne, Adelaide, Brisbane and Sydney. Where the blackfellows crossed narrow streams on fallen logs, white men have built Sydney Harbour Bridge.

Luckily, we do not have to deal in many places with so great a contrast as that between black and white in Australia. In New Zealand, for instance, when Europeans first arrived the Maoris were cannibals, had no writing, had never cultivated the soil nor mined for metals, and they had made only a few rough tools; but today Maoris mix with white people in a way that is impossible for aborigines of Australia. Not only do Maori children go to school with white children (and carry off many of the prizes), but the Maoris are entitled to vote for Maori Members of Parliament.

Inhabitants of South America

Wherever men have met in different states of culture some solution has to be sought for their economic differences if one race is not going

to exploit and oust the other. In many of the republics of South America the aboriginal Indians have practically vanished before the advanced civilization of the white man (see Fig. 16). In the Argentine and in Uruguay the majority of inhabitants live their whole lives without ever seeing a native Indian. A republic like Paraguay, where the majority are Indians, is in a less advanced condition than those republics where the majority are white. Most of the citizens of Paraguay cannot even read and write. Yet before the white men came to South America there flourished an ancient civilization, wholly Indian, at a high level. It would seem from this that conquered races sometimes suffer from discouragement that causes the decay of native culture without stimulating men to adopt the culture of the conquering race. In this connexion, many tribes of Polynesians in the South Seas have diminished in numbers to a remarkable degree since white men came; and some of them seem likely to die out. The ancient tradition has lost vitality in the face of a vigorous new alien culture; but the peoples are as yet unable to benefit from European innovations.

Dangers of Nationalism

We speak of European culture as if it was a thing of which to be vastly proud; and so it is. Yet Europeans seem to have inherited from the Ancient Greeks, who first brought culture to Europe, that jealous patriotism which destroyed Ancient Greece; and some people fear it may as certainly destroy the fine flower of European life. Narrow nationalism is a destructive bug; and so virulent is it on European soil that there is no saying that it will not breed dangerously even in most unlikely places.

There was an illustration of this in Spain before the Civil War. The Catalans, who live in the north-east corner of the peninsula, are a distinct people with their own language. At the beginning of the nineteenth century the ancient language was spoken by illiterate peasants and a corruption of it by the rabble of the towns. Then a scholar succeeded in making it a literary language, and a number of literary enthusiasts created a new demand, in the Catalan tongue, for a new life for Catalonia. The result was that in the autumn of 1934 Catalonia declared herself an independent republic, a new nation apart from Spain. This republic was short-lived. Twenty-four hours of life it had, before its capital, Barcelona, was shelled from the sea and compelled to surrender—its President was imprisoned.

Raising Economic Standards

The local affair of Catalonia has a world-wide significance, in view of the demands of small nations and minorities for a say in the governance of the world. There is much to be said for small nations, as against big ones. A small nation like Sweden, for example, is enabled to give to its citizens social legislation and conditions of life in advance of that averaged by any of the great powers. Among the six million Swedes there is not one who cannot read and write; while the purchasing power of the ordinary day labourer in Stockholm is equal to all but the richest in America; and there are no poor, no slums, in Sweden.

We need not despair of backward

Fig. 16. *Some South American types. The European invaders of South America found yellow-skinned native peoples that varied greatly in customs, languages and culture. The present-day white population are mostly descendants of the original Spanish and Portuguese colonists, while in a large proportion of the inhabitants white and yellow blood are mingled freely.*

peoples being raised to higher standards and so solving the problem of the equation of wealth. Let us remember that whole communities have changed their way of life with extraordinary rapidity—sometimes through the energy and vision of one man, as in the case of Turkey under Mustafa Kemal; sometimes through the vigour and ideology of a regime, as in the case of the illiterate downtrodden Russian peasants and the communities of Central Asia under the Soviets.

Origin of Races

Since, as we have seen, there are no absolute racial barriers between the peoples of the world, there seems no good reason why their cultural and economic activities should not interact to raise and sustain the entire world community. We have noted that the majority of races and nations are interdependent and interrelated. As to the latter, the present scientific conclusion is that the difficulties of accepting the multiple origin of races are so great that the best opinion tends to believe in the common origin of all.

The peoples of the world today exhibit close cultural resemblances in spite of outward seeming differences. Highly artificial forms of language, such as tenses, cases, and grammatical gender, are found overlapping far beyond the bounds of race, however race may be defined.

Comparative anatomists undoubtedly exaggerate the morphological differences between the races, especially between the most superficially different races, such as the black, white, and yellow-skinned groups; and they usually ignore entirely the cultural resemblances which are far too close and too numerous to be explained by airy generalizations about the "essential similarity of the human mind."

But if mankind originated in a common stock it is unfortunate that no satisfactory explanation is forthcoming of the process by which differentiation into races took place. Perhaps men are like grapes, which produce wines of different flavours on different soils. It may be thought that the black peoples, inhabiting tropic and sub-tropic lands, have developed dark skin pigment as protection against the Sun's rays, whilst the white peoples of temperate climes have lighter pigmentation because of the weaker power of the Sun in those regions. This explanation, however, will not cover the yellow-skinned peoples of equally temperate climes, nor show why they should differ from the Redskin nations of North America as to skin colour.

In short, we have a great deal more to find out about the action of climate and natural environment generally upon human morphology before we dare to come to any conclusion about the matter. We can say truly enough that Man throughout the globe has become physically adapted to the Earth's varied conditions, and many hundreds of physical characteristics can be explained on this score. The wide, flat nose of the Negro enables him quickly to breathe up a quantity of hot tropic air, while the long thin nose of the Eskimo causes his inhalation to warm the frozen Arctic air before it reaches his lungs.

Even so, the sum total of these adaptations do not add up to the complete catalogue of what we must still be content to call racial characteristics. All we can say is that it is probable that all men are derived from one stock.

CHAPTER 6

PHILOSOPHY

Scope of philosophy. Ethics, or moral philosophy. Political philosophy. Æsthetics. Metaphysics. The Greek thinkers. Modern philosophy. Evidence of the senses. Faith, opinion and belief. Reality and knowledge. Empiricism. Cause and effect. Moral judgments. Origin of Ethics. Reason, intuition and emotion. Hedonism. Utilitarianism. Motives and consequences. Moral sense theory. Intuitionism. Rashdall's theory of morals.

PHILOSOPHY is a Greek word or rather a combination of two Greek words meaning "love of wisdom." It has often been interpreted as a search for knowledge for its own sake without reference to anything except the precision and exactness of the knowledge gained. In this widest sense, therefore, the subject is one with no limitation to the scope of its inquiries. Every writer and thinker who contributes to the sum of human knowledge may be called a philosopher. Nor is this surprising when we remember that the precise scope of any of the sciences is rarely defined, whilst new sciences with distinctive names are constantly arising as new subjects of investigation are pursued and human knowledge becomes ever wider.

Is, then, physics or chemistry a part of philosophy? In practice the answer of course is no, although thinkers of the ancient world who rank among the greatest philosophers of all times tended to confuse the issue; much of their speculation was on topics which we now consider a part of physics. Some limitation must be made to our definition of philosophy if we are to avoid the pitfall of a subject matter so vague and diffuse that we shall not know at what point we start. So we qualify our original definition by saying that the essence of philosophy is pure speculation, the exercise of reason untrammelled by material experiment, not concerned with the objects of sense impressions, that is, the things we see or feel or hear.

Philosophy is, therefore, the activity of the world of thought and of thought alone. It proceeds by pure reasoning to make deductions and reach conclusions about the nature of ideas and of things which though we assume their existence, cannot be recognized by the senses.

The meaning of this definition will become clearer if we first examine what these ideas are, because each is the subject matter of one of the main branches of philosophy, and these, unlike the parent science, do admit of exact definition, and are definitely restricted in scope.

Ethics, or Moral Philosophy

First is *ethics* or moral philosophy. We place it first, not because it was studied first or because it is necessarily the most important part of philosophy, but because it is the natural starting point for the ordinary man and woman. It deals with the nature of conduct and as such its subject matter comes within the purview of every man. What makes

an action right or wrong? What do we mean to say of an action when we say it ought to be done? What precisely have we in mind when we say that we believe in freedom of the will, or the rights of the individual? Notice that all these questions imply the existence of "things" — freedom, rights, morality, duty—which we certainly cannot see or hear or feel, but the real existence of which we do not for one moment doubt even though, if we were asked, we probably could not even start to define. It is the purpose of ethics, then, to examine these ideas and seek to make our mental picture of them as clear as if we could perceive them with the senses. Plato and Aristotle among the ancient Greek philosophers; Kant, Mill, Bentham, T. H. Green and Hastings Rashdall among modern European ones; are names which stand out as having contributed in a major way to our knowledge of the subject.

Fig. 1. *Jean Jacques Rousseau (1712-1778).*

Political Philosophy

Arising out of the investigation into the nature of conduct is another branch of philosophy, generally known as *political philosophy*, which studies the same ideas in relation to the community as ethics pursues in relation to the individual. To some extent every one of us is a political philosopher whenever we think in terms of democracy or rights, or theorize about the nature of government. How ought a state to be governed, and on what principles? That is the overriding problem of political philosophy. Arising from it are consideration of the nature of punishment, the relation between the individual and the state and the theories underlying the practice of democracy, monarchy, socialism and all the other types or forms into which different kinds of government are divided.

Political philosophy, or politics as it is often referred to, has received a great impetus during the last hundred years, when the average citizens of the civilized world have become conscious of their rights and have refused to accept blindly the relation towards the established government which tradition decrees. In other words, men have begun to think for themselves and have sought ways and means of justifying an active revolt against custom and vested interests. In this sense, philosophy has a very definite link with practice, and the evolution of a particular theory by some enlightened philosopher has often preceded a complete change in the system of government. Thus Rousseau (see Fig. 1) is the inspiration and justifier of the French Revolution, Karl Marx the prophet and spiritual leader of the communist revolution. In another sense Nazi Germany sprang from the

philosophy of Nietzsche, adapted and rationalized by Adolf Hitler. Similarly, in the ancient world of thought, the political writings of Plato and Aristotle did much to establish and clarify the relation between citizen and state in the Greek city states and particularly in Athens.

In recent years political philosophy has been reinforced and to some extent displaced by economics, a subject which is the theme of another section in this book. Marx himself is part economist and part philosopher. The many British writers who have influenced political thought and action from Adam Smith onwards have all tended to super-impose their moral teachings on a foundation of economic theory.

Although we see philosophy thus linked closely with practice and actually determining conduct to a large and important degree, that is not the purpose of philosophy. Ethics, for instance, does not claim to make men moral; there is not the slightest evidence that the most enlightened philosopher is any the more virtuous for being a philosopher. Of course many thinkers on this subject have been attracted to it by a recognition of the paramount importance of the moral part. Many, too, have used moral philosophy as the foundation on which to build a superstructure of sermons; some of these thinkers such as Bishop Butler have been extremely enlightened philosophers as well as divines. But it must be stressed that moral teaching is not the same thing as moral philosophy. Ethics exists to analyse the nature of actions which are right and determine what quality there is common to them all—the quality which constitutes their rightness. It does not purport to lay down rules of conduct or, what is still more important, give mankind the will to do what is right, although it has often been argued that what mankind needs is a lead to the recognition of "the good"—and in this sense ethics may well supply the lead.

Æsthetics

Just as we are all sometimes doubtful about the nature of duty (though we shall probably express that fact by saying "I wish I knew what I ought to do now") so we all are occasionally puzzled by the nature of beauty. And this concept —beauty—is the subject of another branch of philosophy called *æsthetics*. The purpose of æsthetics is to analyse the nature of beauty in just the same way as ethics analyses that of duty. Beauty is one of those things which we all recognize as real, but which we should find it quite impossible to define. Indeed the idea of it seems to vary from person to person. What one judges to be beautiful another may well consider to be ugly. Moreover, standards of beauty vary enormously from one generation to another, from one nation to another. What then is the exact nature of this quality which is revealed in such a bewildering diversity of ways? Is it a quality of the objects which we call beautiful, or does it reside rather in the eye of the beholder? This, of course, is another way of asking: Is beauty objective or subjective? Æsthetics resolves itself largely into a consideration of this problem which is one to which in the nature of things a final and positive answer has never been given—nor probably ever will.

That fact raises another interest-

Fig. 2. *David Hume (1711-1776).*

ing sidelight on the nature of philosophy in general. Philosophical writers usually proceed from an analysis of the reasoning of previous philosophers to some new and original solution of the particular problem they are considering. This is just as true of the great works of philosophy—of the monumental writings of Hume (see Fig. 2) or Berkeley—as it is of the host of books of lesser importance which have been published on philosophical thought through the ages. And, of course, a new point of view is a very good reason—perhaps the only good reason—for producing yet another book on ethics or æsthetics or any other branch of philosophy. But it must be remembered that the true function of philosophy is critical. Each successive writer commits his view, as it were, to the critical consideration of the world—and never yet has a new view been accepted in its full implications by later philosophers. It seems as though any and every view admits of criticism. There is not and cannot be absolute finality. Of the great number of different systems of ethics (for instance) which have been proposed, some of which we shall consider briefly later in this article, none is absolutely foolproof in the sense that the student can be directed positively to this theory or that to accept it as final.

This is one of the reasons why philosophy is such a valuable study for mental training. It makes the student think. In the final instance, the conclusion which the student tentatively accepts is his own conclusion, reached by the exercise of his own mentality. When our subject matter consists as it does of the objects of thought, our conclusions cannot be verified as in the case of the other sciences by the indisputable evidence of things experienced. The only proof of a theory in philosophy is that the mind accepts it without doubt, or if it follows inescapably as a deduction from a premise (or first principle) which cannot be doubted.

Metaphysics

We must now consider the nature of another very important branch of philosophy which we call *metaphysics*. This is so important in the history of philosophy that some thinkers have tended to regard it as the whole of the subject. Certain it is that the moral systems of some of the world's greatest philosophers, such thinkers as Aristotle and Immanuel Kant, depend for their validity on the nature of the metaphysics propounded by them.

Metaphysics may be defined briefly but not exactly as a consideration of the inner or hidden nature of the universe. It arises from a doubt as to the validity of the evidence offered us by our senses concerning

the world about us. Our senses show us a constantly changing world—and indeed, often deceive us about its exact nature. We may "see" something that is not there or imagine that we hear a sound which is non-existent. How then can we trust our senses to give us an accurate impression of the reality of which we form part? Is there not some reality which we can know by the mind instead of having to trust to the senses?

Metaphysics seeks this reality which can be known by exercise of the mind. That part of it which is concerned with the nature of reality is called *ontology*, that part which is concerned with the nature of our knowledge is called *epistemology*. So ontology and epistemology are really two ways of looking at the same problem. Allied with metaphysics is *theology* which is an investigation into the nature of God, and *logic* which is concerned with the way in which the mind works.

It is obvious that any search for the true nature of reality must impinge on pure physics. And as we have already stated, many early philosophers did in fact come very near to being physicists. Conversely, in recent years physicists and mathematicians have turned philosophers—which is not surprising since mathematics is a science of pure reason, of inference and deductions very similar to the essential processes of philosophy. So the work of Dunne in the theory of the nature of time, and of Einstein in the theory of relativity have made contributions of first-rate importance to the body of philosophical thought.

In the outline which follows we will consider a few of the principal aspects of metaphysics and ethics, and indicate some of the answers which the greatest of philosophers have given to the problems involved. Our purpose is to show how the same kind of problems run through the whole history of philosophy and to indicate the gradual evolution of thought which has occurred through the centuries.

Necessity of Reading

Here a warning note must be sounded. The best way—indeed the only sound way—to organize the background of philosophical thought is to read the works of the great philosophers themselves. The principal works of those who wrote in English are mostly available in several cheap editions, whilst the ancient Greek philosophers and those of many other languages (in particular modern German) have been translated very adequately into English. In the course of the present summary we shall name a few of the most significant or interesting works. These must be treated as source books, if philosophy is to be studied in a serious way. From them the student can proceed into the by-ways of philosophy and gradually develop judgments of his own; for the right attitude of the philosopher (and every one of us can become a philosopher in that sense) is not to accept blindly what he sees printed or hears spoken but to bring the critical faculty to bear on any and every statement of opinion. To this end, reading and still more reading is the only sure method of approach.

One other point must be remembered. Some limit must be placed upon the range of works which can be treated as source books. Every

civilized nation of every age—almost without exception—has produced its growth of philosophy. Indian, Chinese, Persian—some inspired by religion, others not—a bewildering array of teaching from every conceivable point of view. Partly because it is quite impossible for any one person, however wise and enlightened, to grasp the essential elements of so many and such diverse systems of thought, partly because many of the Eastern philosophies are out of touch with modern European methods of thought, it is usual to restrict the study of philosophy to a single connected family tree of writings.

The Greek Thinkers

For many reasons, the study of philosophy must include the work of the ancient Greek thinkers, among whom Plato and Aristotle are supreme. In particular, the Greeks evolved a scheme of philosophy which is not far removed in approach and thought from a system applicable at the present time. Some of the conclusions of Aristotle have had to be discarded in the light of modern science, but surprisingly few. The tradition of the ancient Greeks survived through the era of the Roman Empire though the Romans themselves proved comparatively arid in original thought. Even the dark ages of medieval Europe did not dim the light of Greek thought, and when the Renaissance came to Europe, it was to the Greeks that the new race of scholars naturally turned for inspiration. The most modern British, American and European thought is, of course, in the direct line of descent from the Renaissance scholars. So, in practice, philosophy as we know it comprises this single body of tradition which includes in fact a very high proportion of the world's total inheritance of knowledge.

We start, then, with the work of the Greek thinkers of the classical period, two thousand five hundred years ago. Though Plato and Aristotle are pre-eminent among these, they did not appear suddenly like meteors in the sky, trailing their brief cloud of glory and then burning themselves out into dim obscurity. Rather they followed in the train of many lesser stars and were followed in turn by many satellites, a few of which even succeeded in enhancing the noble Greek tradition of thought. Both Plato and Aristotle too, owed, like most other philosophers, a very great debt to those who preceded them in the history of thought.

Everything Changes

It was Heraclitus who first rationalized a phenomenon of nature which may be said to be the starting point of philosophy's search for a permanent unchanging reality to explain a world which is constantly changing and of which the constituent parts are so obviously impermanent. It was in fact Heraclitus who stressed the fact that you can never step twice into the same river, in so far as the particles of water which compose the river are never the same for two minutes in succession. A later philosopher went further than this, saying you could not step once into a river! He meant, of course, that in the very moment of stepping, the particles of water had changed their grouping so that the river you actually stepped into was not the river you had willed to step into.

We must examine this difficulty

a little more closely in order to appreciate the background of Greek thought. It is summed up in the Greek words *panta rhei, onden menei,* which may be translated: "Everything is in a state of flux." And this is a statement with which the findings of modern science are in complete agreement. Whatever it is that we are considering, animate or inanimate, the same process of change can be observed. A child is conceived, born, grows to maturity and dies. After death the tissues of the body are changed into other forms—"from dust to dust." There is no single point of time at which we can say "*that* is the man" or if we do, as soon as we have said it another stage of development or decay has begun, and our search for the permanent unchanging you has been in vain. This is true of everything we apprehend with our senses—of everything we see or feel or hear, in short of everything which is material and has extent and solidity.

What then lies behind all this? For the human mind cannot accept the supposition that there is nothing immanent in the world, no sheet anchor, as it were, to which the ship of human endeavour and experience can cling, and in which it can have faith.

Religion supplies an answer. God is the one permanent and real thing, the very essence of reality in a changing and impermanent world. And this indeed is an answer which medieval and later philosophers sought to demonstrate. But for the Greek thinkers (or at any rate the early ones) it was not the answer for which they were looking. Greek religion was a religion of many gods, who were in some ways subject to the laws of the universe as we know it. Their functions were clearly defined and these did not include being the source and origin of the world. What the Greek philosophers sought was a single element from which the material substances of our world develop and into which they are changed again when they decay.

Thales, one of the earliest of the classical teachers, had suggested water as the single all-embracing element. Heraclitus suggested fire. It must be stressed that this was no allegoric appeal to water and to fire. The suggestions were in both cases intended literally. And one can see that the solution to the problem offered by Heraclitus would commend itself to a people whose knowledge of physics was strictly limited. Heraclitus was called the "weeping philosopher" because his statement of the fact that everything is in a state of flux was regarded as extreme pessimism. Yet there is one thing to be said in favour of his philosophy. It started from a sound premise and did not reject a conclusion merely because it was contrary to accepted opinion.

Socrates and Plato

The next school of philosophical thought which we have to consider is on a much more mature level. Socrates (see Fig. 3), Plato and Aristotle together form a single link in the chain of our inheritance of knowledge. Socrates was a teacher in Athens in the fifth century B.C. He was condemned to death on a charge of corrupting the youth of the city. But although he was a great teacher, he probably never committed his thought to paper. In any case, none of his writings, if any existed, have survived.

Plato is his able interpreter, for

Fig. 3. *The death of Socrates (about 400 B.C.). Condemned to death by an Athenian court for "corrupting the young" with his philosophical teachings, Socrates died by drinking a bowl of hemlock.*

Plato puts into the mouth of Socrates the greater part of his philosophy. It is difficult indeed to know where Socrates ends and Plato begins. Aristotle was a pupil of Plato and at first a keen admirer and follower, but in his later writings he differs from Plato in many essential details.

Theory of Ideas

Both Plato and Aristotle have been excellently translated into English, so that students without a knowledge of Greek need have no difficulty in reading these two great philosophers in the original. Plato's greatest work is *The Republic*, but some of the *Dialogues* give a better notion of the theory of ideas than does *The Republic*.

In general principle, Plato accepted the position of Heraclitus that everything is in a state of flux. But he differed from Heraclitus in the kind of solution he offered to the problem: "What is permanent?" To Plato it seemed that only the world of experience was subject to the laws of change—only the things which we apprehend by means of the senses. In this, incidentally, he came very near to the conclusions of many modern philosophers, including Kant. It seemed to him that in addition to this world of the senses, there must exist another world of things which could only be apprehended by the mind—and these objects of the intellect must be real and unchanging in contrast with the changing and impermanent nature of the phenomenal world.

These "things" apprehended by the mind Plato calls the "ideas" or forms—and his theory generally is

Fig. 4. *Francis Bacon (1561-1626).*

known as the theory of ideas. Plato's "ideas," of course, are not similar to what we mean in ordinary language by an idea. The main distinction is that when we speak of an idea, we imply that it has no existence independent of our thinking of it, but for Plato the ideas are real and objective, the only things, in fact, which have true reality. They are the "forms" of which the objects which we generally call real (that is the things which we apprehend with the senses) are copies.

If we follow Plato a little further, the meaning of this becomes clearer. According to his theory, art is debased because it in turn copies things which are themselves copies of true reality—the ideas. This makes the position clearer because it appears that a table, for instance, is related to the idea of table in the same way that a drawing of a table is related to the table from which the drawing is copied. So men and women are not truly real, but are copies of ideas which we may call manhood and womanhood.

Nature of Knowledge

In considering the nature of knowledge, too, Plato had an equally provocative contribution to make. The point at issue (and this is a problem which has been the theme of very many later investigations into the nature of knowledge) is whether what we know is derived entirely from experience or whether some of it may rightly be said to be gained by intuition. We shall have more to say about this later, but for Plato the answer without a shadow of doubt was that a good deal of what we know is in that sense intuitive; that is, we do not gain it by experience. In this he is in agreement with many modern philosophers, but his reason for reaching the conclusion is unique; for it follows from his statement of the reincarnation of the soul. The body dies, but the soul lives on and enters another body. So what we know by intuition is really what we remember from a previous incarnation, knowledge gained when our soul was in a different body.

Aristotle's Reasoning

Aristotle took up Plato's thought where Plato left it, and went a good deal further. He accepted the Platonic position of an impermanent and therefore not truly real world which is apprehended by the senses and of another true reality that can only be known by exercise of the mind. But he rejected the Platonic theory of ideas, at least in so far as it laid down that the material thing was a copy of the idea, or ideal, form. For Aristotle the real world was a world of "universals" (not really so very different from the Platonic ideas) and material things were only real in so far as they partook of the essence of the universal.

Aristotle distinguished also between different qualities of things.

Suppose, for instance, we see someone whom we describe as a tall red-headed man. We are here combining, according to Aristotle, the ideas of size, colour and humanity. Only the last of the three is substantive or real, and the man is real in so far as he partakes of humanity. But the size and the colour are variable in nature and are qualities that have no reality apart from the man (or other material object) in which they are expressed.

Another way of looking at the Aristotelian idea of a real universe that can only be perceived by the mind is to define it as a distinction between form and matter. The form of a thing (corresponding to Plato's idea) is the essential reality of an object, the matter is a realization of the form perceptible by the senses. In Man the form is the soul, the matter is the body. Matter according to Aristotle is composed of the four elements: fire, water, earth and air. But there is another element, not realized in the world we know, which he calls quintessence. It is this element which gives reality to the higher spheres of the universe in which form and matter are united.

Aristotle's Influence on Medieval Thought

The main principles of Aristotle's philosophy are set out in the *Metaphysics* and the treatise generally referred to by its Latin translation *De Anima*. To read these works, and especially the former, is not only to gain an insight into Aristotle's thought, but into philosophical method in general, especially as the problems discussed are for the most part the self-same problems which have been exercising the minds of the philosophers all through the centuries.

There is an element of mysticism in the works of Aristotle though his philosophy is mainly rationalistic (by which we mean appealing to sober reason rather than to faith). Throughout the rest of the classical period and well into the Middle Ages, Aristotle was not forgotten, but the mystical elements of his thought were accepted to the exclusion of the more rational parts. It was certainly Aristotle who inspired the work of such great medieval philosophers as Thomas Aquinas and Duns Scotus. With the Renaissance came greater independence of thought, as shown for instance by the works of Francis Bacon (see Fig. 4) and by the *Leviathan* of Thomas Hobbes, which every serious student of philosophy should read.

Modern Thought

Modern philosophy is generally said to begin with Descartes (died 1650) and it is certainly true that this great Frenchman started a train of thought which has been carried on without a break to the present day. If we consider briefly the nature of the problem as he saw it we shall have surveyed the characteristic difficulties of modern metaphysics. The *Discourse on Method*, and the *Meditations*—two of Descartes's most important works—are both available in English translation.

Whereas the starting point of classical thought was a search for a permanent reality in the midst of a changing world, modern thought has been stimulated rather by doubt as to the validity of the sense impressions which we receive. Once the seed of doubt is sown, the harvest is surprisingly great. What,

then, is the nature of this doubt? And what do we mean by sense *impressions?*

Before going further we will try to discover an answer to these two questions. We often say: "I know that because I saw it," or "I'm quite certain because I heard him say so." In other words, we often claim to know something because we have seen it or heard it, or for that matter apprehended it with any of the senses, of which sight and hearing are two. We are quite sure that we know what we see or hear. And that is the trouble—sometimes our senses deceive us.

The classic example of sense impressions being misleading is that of the parched traveller in the desert who on breasting a long slope, looks down into the valley and there sees an oasis in which he can count the palm trees and see the reflection of dwelling places mirrored in the lake. But as he presses on the mirage as we call it, fades, and all he finds there is sand . . . and more sand. The traveller is in the position of a man who sees, yet does not see. His sight has deceived him. And if it has deceived him this once, how can he ever trust it again?

Another oft quoted example is that of the man who suffers from "head noises." Again and again he hears bells ringing or whistles blowing, or people talking, but the sounds turn out to be a product of his physical condition—an abnormal one admittedly, but how shall one with certainty distinguish between the normal and the abnormal? It is just as easy to discredit the other senses as it is those of sight and hearing.

So, we conclude, there is an element of doubt involved in the reception of every sense impression. The individual cannot be absolutely sure that he knows what he sees or hears. But the vast bulk of what we call knowledge is derived ultimately from these and similar sources. Therefore, if we are to be completely rational, we must doubt the truth or validity of everything that we think we know.

Descartes' Philosophy

Doubt is the starting point of what is often called philosophical scepticism. And it is the point from which Descartes commenced to build up his system of thought. "Granted that I must doubt everything which I thought I knew," he said in effect, "is there nothing at all to which I can cling with absolute certainty, nothing of which I can say positively I know?" In his view there is one thing which I really know and only one, namely the fact of my own existence. I am conscious of the operation of my brain, which is implicit in the very fact of my being able to doubt. Therefore I am quite certain that I exist as a thinking being. That is the meaning of the Latin words *cogito, ergo sum* which are quoted as the keynote of Descartes' (see Fig. 5) philosophy and of much of modern thought.

With this one certain and fixed fact Descartes went on to "prove" the real existence of a world recognized by the mind and not depending for our knowledge of it on the validity of our sense impressions. Incidentally, Descartes postulated as part of his system the existence of God.

This latter fact is of great interest in the history of philosophy because, though many philosophers have sought to give a logical proof

of the nature, or of the very existence of God, no proof has yet been propounded which has received general acceptance. The modern view is that proof of God's existence is not possible, but at the same time is not necessary. In other words there are different states of mind in reference to what we know, and we do know in one sense some things of which there can be no logical demonstration.

Faith and Knowledge

It is important to understand the distinction between faith and knowledge, opinion and belief. It is a matter of dispute, certainly, how much we know and how we know it. But of a certainty we do know some things to be true and we can

Fig. 5. *René Descartes (1596-1650).*

make logical inferences from these known facts. If the inferences are correct, the resulting statements are as true as the premises or starting points from which the inferences are drawn. And we may be said to know the truth of these statements.

Faith is of quite a different character. No special activity of the mind, no logical inference is involved. A man who has faith may be said to "know" certain truths without requiring logical demonstration or proof. His state of mind is one of just as great a certainty as that of a man who knows a truth by any logical means. Now the important thing about faith is that it cannot be denied or refuted—that is, provided it is genuine faith and not a mental aberration. Man differs from animals principally by virtue of possessing reason and anyone who is incapable of reasoning cannot be described as a normal human being. If, then, anyone has faith in a truth which can be demonstrated to be false and continues to maintain faith after its falsity has been logically demonstrated, such a person is mentally subnormal. If, on the other hand, anyone says: "I have faith in the truth of such and such, even though its truth cannot be logically demonstrated," that is a perfectly normal attitude of mind and in its own way perfectly reasonable.

It follows, then, that faith can only apply to a certain number and kind of things, in particular those ideas of which it is not possible either to demonstrate the truth or the falseness. And, of course, the existence of God and the attributes attached to the idea of God are pre-eminently in this group. Which is why Descartes's attempted "proof" of the existence of God, like many other proofs put forward by other philosophers and divines, is not entirely satisfactory.

Opinion and Belief

With the distinction between knowledge and faith in mind we can proceed with more assurance

to distinguish between opinion and belief. We may hold an opinion on the basis of very slight evidence. The state of mind which lies behind opinion is that of the man who on the evidence available, reasonably assessed, inclines to a certain view. So far as we hold an opinion we do not claim to "know"—the two states of mind are mutually exclusive. As evidence accumulates to support our opinion and in the absence of any evidence contrary to it, our opinion reasonably becomes stronger until we may say that "we believe such and such to be true." So in a sense the three terms—opinion, belief and knowledge—reflect three states of mind in an ascending scale of certainty.

Great confusion of thought arises if we fail to distinguish in our own minds between these three—any impartial examination of public speaking and writing shows how disastrously the three are confused by many who have least excuse for doing so. It is so fatally easy to try to convince an audience by claiming knowledge when only opinion or belief can reasonably be claimed. It is equally easy and equally fatal for an audience to accept an opinion as fact and then proceed to argue from the opinion to inferences which can be drawn from it and which would only be valid if the opinion on which they are based were really fact.

It remains then to consider the questions: "What is knowledge? What do we really know? Is there anything in all the world of which we can be quite certain as opposed to holding as an opinion?" We have already considered the answer which Descartes gave to this question. But other philosophers have given vastly different answers, and it is now necessary to consider one or two further difficulties which arise from these various theories.

Locke's Empiricism

John Locke, a philosopher, whose work was produced in the second half of the seventeenth century, has been described as the founder of *empiricism*. By this is meant that he was the first of the great philosophers to declare that our knowledge is derived entirely from experience—from what we see and hear and feel and the inferences we draw from what we experience. In the *Essay Concerning Human Understanding* this doctrine is elaborated. According to Locke we have no "innate ideas," we are born, as it were, with minds like blank sheets of paper, on which experience inscribes gradually the pattern of things which we call knowledge.

On the vexed question of the nature of reality, too, Locke contributed a new theory. He distinguished between primary and secondary qualities. The former, he argues, are real and objective and include all the qualities of objects which are capable of exact definition, such as size and extension. The secondary qualities, however, such as colour, are rather in the eye of the beholder and are not part of the real nature of the objects of which they are qualities. They vary according to the light in which they are seen or the direction from which they are looked at. And indeed, every one of us can bear out this distinction from our own experience, for does not a cloth, for instance, appear quite a different colour in the full daylight from what it does in artificial light? Who shall say which is its real colour!

But the nature of reality and the

Fig. 6. *A. Schopenhauer (1788-1860).*

relation between reality and our ideas (like the search for a permanent and real world in the midst of the changing world of the senses which we have already discussed), are problems which run through the whole history of metaphysics. Locke started a tradition which was progressively criticized by George Berkeley and David Hume. The *Principles of Human Knowledge* of the former and the *Treatise on Human Nature* of the latter are two very positive milestones in the history of the subject.

Kant, Hegel and Schopenhauer

The so-called German School of philosophy attacked the problem of reality from a different angle—namely, from an analysis of human reason. Kant's *Critique of Pure Reason* was the corner stone on which this new tradition of philosophy was founded, and in the work of Hegel and Schopenhauer (see Fig. 6) nineteenth-century thought reached its most complete fulfilment and at the same time a most complex character—so complex indeed, that there has been almost as much dispute among interpreters of these philosophers as to what precisely they intended to convey as there has been concerning the truth of their conclusions.

This much at least can be said with certainty. The ordinary man can live and die without questioning the nature of reality and without reflecting on the source and reliability of human knowledge. But once the seed of doubt is sown—as surely it must be in a thinking mind—the problems involved loom larger and longer and, just for the very reason that knowledge is one of the things called into question, cannot be resolved with a positive statement of fact which will satisfy everyone. Nor are the problems such that they can be solved and the solutions verified in the light of experience. The intellect and Man's capacity for reasoning are the only keys which can be used to open the door: these are keys which every one of us has to greater or lesser degree—keys which only become effective by constant practice.

Cause and Effect

There is one item of knowledge which is everywhere known and appreciated without calling for proof—almost, one might say, a universally recognized law of the Universe—namely, that "every event has a cause." It is this law of cause and effect, as it is generally called, which seems to refute Locke's theory that we have no innate ideas. But, however we come to know it, whether as part of our inherited nature, or by experience, or by intuition, at least it is something of which the truth cannot be denied.

It is of very special interest because

from it springs the philosophy of history. It is argued that since every event follows inevitably from its causes, the similar causes tend to produce similar events. In other words, that history repeats itself. Certainly the theory is commended in the light of experience, and in the broadest sense the proposition seems to have been proved again and again. There is a definite rhythm, for instance, in the rise and decline of individual civilizations and in the development and decay of empires.

Some thinkers have gone further and sought to prove that the future can be foretold with certainty if only the events of the present and past are studied with sufficient care. It is recognized, of course, that such a forecast can only be approximate in so far as it is outside the scope of human capacity to recognize all the causes which have contributed to produce a given event.

To accept the theory without reservation would be a confession of defeat. It would imply that whatever we or other members of the human race achieved, whatever sacrifices we made, nothing would alter the predetermined course of history. Therein lies the weakness of the case, for it leaves out of account the human element. If we assume that Man has free will, then Man is literally free to act as he wills in any circumstances. Now history is made up of the actions of a vast multiplicity of men and women. So long as we assume in all of these a true freedom of the will, we can say with certainty that history does not repeat itself necessarily, that to forecast the future is not so much difficult because of the need to consider many factors outside the ken of any individual as impossible because of the incalculable factor of free will. Where free will is not concerned however, as in movements of the heavenly bodies, we can forecast future events with absolute certainty.

Moral Judgments

Earlier in this section it was said that ethics, or moral philosophy, concerns itself with topics which are the commonplaces of everyday life. It will be seen, however, that the answers proposed for the principal ethical problems are no more obvious nor any more certain than in the cases of those other branches of philosophy which have so far been discussed.

Our main problem is: "What is duty?" What is the exact meaning of "ought"? How does the ordinary man judge what is his duty in any particular circumstances? Now it might seem at first glance that we all know the answers to those questions. Certainly many of us are very prone to bestow moral praise, or more often blame, without any special qualifications for doing so.

We say with some certainty: "Smith ought not to have done this or that," or perhaps: "That was a rotten thing to do"—which amounts to the same thing. What precisely do we mean, or more exactly, on what sure basis of fact are we making our judgment? When we come to consider the matter with more care, of course, we find very often that there is very little basis of fact at all. Generally what happens is that we observe some action of Smith, and, recognizing that it is in some way similar to a class of actions which we generally think wrong, we subsume it under that class and, therefore, judge the particular action wrong. But we are

so illogical that we frequently condone an action in one we like when we should condemn it out of hand in one we do not like—which of course undermines our whole position as moral judges.

To take a crude example: if we hear that Smith has assaulted Jones without obvious provocation, we should generally say that Smith ought not to have done it—and in saying so we make a moral judgment. But if we knew and liked Smith we should probably "give him the benefit of the doubt," and assume that there was some provocation which "justified" the assault. That might or might not be true, but at any rate, when once the provocation is admitted as a determining factor in making our judgment, it is no longer "assault" simply which we are judging, but a particular kind of assault, namely assault without provocation. Then it becomes a question of how much and what kind of provocation can justify assault. And in solving that problem we shall get no help from appeal to a simple general rule of conduct.

Briefly, then, it appears that the grounds for making a moral judgment are not nearly as simple as they appear. If they do appear simple it is because we are often guilty of muddled thinking. And though we glibly accept general rules of conduct—"Thou shalt not do this or that"—we are generally prepared to make exceptions in particular circumstances (for instance in the case of Smith the circumstances of possible provocation). Once we start considering the circumstances of the particular action, the general rule falls to the ground, because no general rule can be so complex and complete as to take account of any and every circumstance.

Are there, then, no general rules of conduct? The answer to this is: "None, except those in which there is implicit a further moral judgment." Consider: "Thou shalt do no murder"—a general rule of conduct if ever there were one. Surely, it will be said, this does not admit of exceptions. Of course it does not, but it does imply a further moral judgment, for it means: "Thou shalt not kill except in circumstances in which it is right to kill." It is just that we do not call killing by accident, or the execution of a traitor by the state murder. Before we can say that murder has been done, we have got to judge not only that a killing has taken place (a simple enough judgment), but also that the killing was deliberate and not justified by the circumstances (an extraordinarily difficult judgment). In other words, the general rule: "Thou shalt do no murder" is no help to us because the word murder begs the question—as indeed is obvious when we bear in mind that in civilized countries the whole panoply of justice, of judge and jury and barristers, is brought into operation to determine that seemingly very simple problem: Has murder been done?

Differing Codes of Conduct

We have seen that metaphysics and the theory of knowledge arise from a form of philosophical scepticism. What we have just been discussing is one basis for the corresponding scepticism which is the basis of moral philosophy. On reflection we shall find ground for an even greater scepticism, for it can be pointed out that in different

countries, perhaps equally civilized ones, different standards of conduct are approved. Some actions, such as infanticide, or abortion, or polygamy, which we consider utterly wrong, have been or are in accordance with the law and the moral conscience of other highly civilized nations. There is no real ground for supposing that we are more enlightened than some other peoples. Yet we are prepared to back our moral judgments and our legal code against all comers. So probably are the people of the other nations. Those whose customs we consider barbarous may well harbour the same kind of thoughts about our customs. So the idea arises that perhaps morality is a matter of convention or habit, and that "the right" and "the good" and the idea of what "ought" to be done are convenient fictions to assist in the enforcement of rules which are no more than temporary expedients.

The general trend of ethics has been to disprove this basis of scepticism and to put in its place a definition as it were of duty which will not be subject to the exigencies of particular times or circumstances. But it must be admitted that no general agreement has resulted and there are still several theories well enough supported by the authority of great philosophers from which the student can choose.

Origin of Ethics

Historically, ethics has its origin in much the same doubts which assail thinking men and women of the present day. It may be said that moral questions of one sort or another arise as surely as Man congregates in society, that is to say as soon as Man the individual merges into Man the member of a tribe. For the crudest tribal customs bring with them the ideas of rights and obligations even though the ideas may not be known by those names. It has been argued that the possession of a moral faculty is what primarily distinguishes Man from animal. And certainly this is true in so far as the moral faculty implies judgment and Man is the only one of living creatures which is capable of reflecting on and judging his own actions.

Thus Man, considered as a living organism capable of moral action, once he is conscious of this capacity for distinguishing between right and wrong, must inevitably seek authority as a backing for his own doubting and hesitant searching after the truth. And the taboos of primitive societies are the first coherent attempts to provide that authority. Later in the development of civilization, religious or inspired teaching takes the place of the simple taboo. And still later, systems of laws seek to codify the principles laid down by religion.

Laws and Moral Codes

Religious authority is effective so long as the citizen does not become reflective, and faith holds sway over scepticism. Most civilizations of East and West, in most recorded periods of the world's history, show the same ordered development of thought. But sooner or later there are always some who develop doubts and cease to have absolute faith in the prevailing religion. Once that doubt arises the whole fabric of the moral code is undermined. Laws by themselves without the support of a religious backing are of little avail. For one thing they are capable of being

changed and, in fact, in most countries do change materially from generation to generation. But the whole conception of duty, of right and of "the good" is one of permanence. One's duty, it is felt, remains essentially the same, however much the laws may change. Moreover, laws seldom march far behind public opinion. So far as they are man-made and man-enforced, they must carry with them some measure of popular support. But in fact a system of laws which at best is a kind of general guide can never take the place of a personal moral code which is essentially particular and individual. Finally, it is in the nature of laws as of primitive taboos to prescribe mainly what must *not* be done, and to lay down a scale of punishment for transgressors. Morality, by contrast, is a very positive thing and consists more of doing right actions than of refraining from doing wrong ones.

Defining the Good

So reflective Man — Man the philosopher — seeks an internal standard. We will now consider a few of the many internal standards proposed. Aristotle in his work *The Nicomachean Ethics* put forward a very complete system of moral philosophy—which we may take as representing the best of ancient thought on these matters. "The good," said Aristotle, "is that at which all things aim. And Man aims at happiness. Therefore happiness is the good of Man." Actions are right in so far as they tend towards promoting this happiness or well being, wrong in so far as they do not. The particular virtue of every species is to be perfect in the carrying out of the function to which by nature it is specially adapted. This function in the case of Man is the reflective life, and therefore the completely good and virtuous man is the one who is happy in the pursuit of knowledge, who in a sense subdues feeling to reason. It is interesting to note that the Greeks had no special word for "morally good," any more than we have. Whether they were speaking of a good man or a good horse it was the same word and by "good" they emphatically meant good for something, that is they did not tolerate the goodness of mere inactivity which some modern philosophers have been prompted to propose. There was no question of being good merely by refraining from breaking moral laws. Goodness was to be judged by activity of a purposeful kind. In this it is possible that the Greeks in general and Aristotle in particular had a good deal to teach the exponents of the popular *laissez-faire* school of thought.

Aristotle set reason in opposition to feeling. The relation between these two is one of the most important problems of modern ethics. It has often been argued that because it is the possession of reason which distinguishes Man from all other forms of creation, therefore reason ought to be developed to the exclusion of feeling. Behind this theory, of course, is a judgment to the effect that Man is superior to the animals, and reason is the factor which makes this superiority real. Nor is this only a matter of theory. Much religious teaching has been directed to the subjugation of the passions, and, as we have seen, Aristotle tended to discount feeling as of any particular value.

The argument is false if carried

to its logical extreme. We have all met people who seem to direct their lives by reason alone, who are never swayed by emotion, but we do not judge them particularly good on that account. We may admire the continence of the celibate, but if all men were celibate there would be no next generation even to reflect on virtue. The history of medieval monasticism shows that retreat from the world of emotion in search of the reflective life, and devout self denial, often defeat their own ends. In any case the virtue of the inactive is not really worthy of so much moral praise as that of men and women who are exposed to the normal temptations of daily life.

Value of Emotion

What, then, is the truth underlying the very common tendency to regard reason and feeling as mutually contradictory? It is simply this: feeling is a property of all (or most) living creatures and the fulfilment of bodily pleasures is one which Man desires in common with animals. It is, in fact, instinctive in Man, and so far as one form of self-indulgence is essential to the survival of the race, it must be judged valuable, unless racial suicide is judged to be a good aim (which is clearly a ridiculous suggestion). It is true that reason is the peculiar property of Man and that by the use of reason Man is able to regulate his instincts and pass judgment on his emotions. But that does not mean that Man ought to subdue his instincts and emotions—in general his life of feeling—or ought to aim at a state of affairs in which he is no longer capable of feeling or of appreciating sensual pleasures. After all, historically, feeling precedes reason. There is no evidence to show that what develops later in the history of evolution is necessarily superior to what already exists. It is surely logical to suppose that in Man there ought to be a perfect synthesis of reason and feeling, a state in which each takes its proper part—in which Man judges his emotions and feelings, and regulates his actions in the light of reason. Thus he will not act blindly as feeling dictates, but will take due account of his feelings in judging his proposed actions.

Perhaps the more austere view would not have received very much support if it had not been for the recognition of the "moral struggle" as an integral part of moral man. The "moral struggle" is something of which every thinking man and woman must be aware in his makeup. It occurs when we are conscious of desiring some particular end, usually pleasure, but are also conscious that we ought to do something different. An example will make this clearer. On a warm and sunny day, we may be conscious of a strong desire to leave our work and sun ourselves in the warmth of the open air. But we may at the same time recognize that we ought to continue with our work—whatever we feel about it. We are then conscious of a moral struggle as these two conflicting impulses are resolved. In so far as we are "moral" and "reasonable" we shall, of course, judge that we ought not in these circumstances to do what we desire, but that does not imply that we ought never to do what we desire, whatever the circumstances.

There is much evidence of this confusion of thought in modern ethical writings. We have considered briefly the attitude of the most enlightened of the ancient

world as evidenced by the theories of Aristotle. In modern times, perhaps as a revolt against the ascetic traditions of the Middle Ages, the accent has tended to be on the value of happiness.

Bentham's Hedonism

The philosopher Jeremy Bentham (see Fig. 7) first propounded the theory of "the greatest happiness of the greatest number"—a principle which has probably had more influence on political and moral thought than any other creed.

According to this principle an action is right if it brings about the greatest quantity of pleasure possible, wrong if it does not; a man's duty is to be measured by his capacity to ensure the greatest possible amount of pleasure, irrespective of considerations about the persons for whom this pleasure is produced.

The theory that duty consists of the bringing about of happiness for the greatest number is known as *hedonism*, from the Greek word for pleasure. It is open to several vital objections. First and most important, it leaves out of account entirely that class of duties which are generally known as "particular" obligations—such as the duty of paying a debt, and the duty which a parent owes to the children. Secondly, it leaves the idea of justice with no significance. Pleasure, it says in effect, must be distributed with only quantity in mind and with no regard to justice. But to admit this would falsify the whole fabric of civilization which is based, so far as its laws and customs are concerned, on the theory that merit shall have its reward, irrespective of whether this reward could be

Fig. 7. *J. Bentham (1748-1832).*

distributed unjustly with greater pleasure to someone or other. To take an example at random, if hedonism is admitted, a trustee who holds moneys in trust for the heirs of a deceased man would be doing his duty if he failed to give the moneys to the rightful heirs, providing he believed that giving the money to someone else would give more pleasure on the whole. He would, in fact, be perfectly justified in appropriating it for himself! No hedonistic calculus, however involved, can make this position accord with the idea of duty. And it must be remembered that it is the function of moral philosophy only to explain moral action, not to dictate it.

Psychological Hedonism

In view of the failure of hedonism to give a rational explanation of "duty" and "the good"—perhaps because of this failure—another theory which has often been confused with it is sometimes argued. This theory, called *psychological hedonism* by some philosophers, suggests that whether we wish it or not, all our actions do in fact tend towards our own pleasure: are, as it were, designed for our own satisfaction. It states that we are not capable of acting in any other way; when we appear to be

unselfish we are really acting in that way in order to secure the pleasures of a good conscience.

This is another theory which strikes at the roots of civilization, and indeed denies to Man the capacity to be moral; for if we can only act in the way which we think will be most pleasurable or beneficial to ourselves it is meaningless to say that we ought to have acted in some other way. Now a theory which rests on a dogmatic assertion as to human psychology can only be refuted by evidence showing that its analysis is incorrect. And this evidence is provided by the reality of the moral struggle to which we have already referred in this chapter.

So far as we are conscious, as we all are, of freedom to choose between two actions, the one representing what we believe to be our duty, the other what we desire to do at the moment, by that very consciousness of a choice we disprove the theory. For if the theory were true we should have no choice. Moreover, it is not conceivable that the idea of duty is a universal delusion. Even if it were, it would still remain for ethics to analyse the nature of this delusion! For assuredly when we speak of an action being right or wrong we do mean something by the phrase.

Mill's Utilitarianism

Against the background of hedonistic thought, the most important theory of John Stuart Mill (see Fig. 8) is more intelligible. Mill called it *utilitarianism*, and though it is doubtful if he would recognize as his own creation some interpretations which have been put on the word, it is certain that it has gained and still holds a vast number

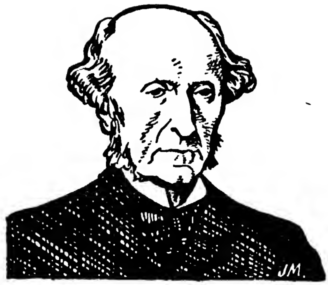


Fig. 8. *John Stuart Mill (1806-73).*

of adherents. Recognizing that reflection rejected simple pleasures as the only rational object of mankind, Mill suggested that it was not pleasure alone that we ought to secure but certain kinds of pleasure, in particular good pleasures. To put this in more precise language, what Mill suggested amounted to a qualitative rather than a quantitative judgment of pleasure. And because of much confused writing on the subject this distinction between good and bad pleasures is one that commends itself to many people. But it cannot really be supported. Pleasure is a state of consciousness. It is something we feel, in the same way as we feel heat, or cold. We can feel pleasure and its opposite, pain. We are aware of them as states of consciousness. We can feel more pleasure or less pleasure but we cannot feel better pleasure or worse pleasure. What we can do, and do, is to feel pleasure and judge that the objects or activities from which it is derived are good or bad, or we may judge that we ought, or ought not, to enjoy a particular pleasure.

The distinction is an absolutely vital one, for it undermines the foundation on which Mill's theory is built. It amounts to this—that

when Mill says that duty consists in bringing about a maximum of good pleasure, what he really means is that we ought to bring about pleasure, but not without reference to the circumstances, or the consequences, or the objects, from which it is derived. So pleasure ceases to be the only rational object of action.

This argument disposes of utilitarianism as such, but it leaves a basis which Hastings Rashdall developed in the *Theory of Good and Evil*, one of the most complete systems of moral philosophy ever written in the English language. And it also leaves us with a residue of truth, which may be expressed by saying that it is very doubtful whether any action can be conceived of as right unless it brings some pleasure or satisfaction to someone, even though that pleasure may not be the greatest which could have been produced in the circumstances which determined the action.

Before we proceed to analyse the important work of Hastings Rashdall there are two theories of quite a different kind which deserve brief consideration. All that we have said so far presupposes that it is the consequences of an action, either real or imagined, that constitute its rightness or wrongness. For instance, if we say that we ought to produce happiness, we are definitely looking to something that will follow the action as a direct result of it. But it is sometimes argued that Man is fallible and cannot possibly foresee what will be the consequences of any action, let alone base his action of duty on an exact calculation of those consequences. So some philosophers have held that the results of an action have no connexion with its rightness. Kant, for instance, held that the only thing in the world which can be called absolutely good is the goodwill—the will to do what is right and reasonable as such.

Kant in other parts of his ethical writing contradicted himself by deducing from an examination of pure reason certain general rules of conduct—such as: "Never treat mankind as a means only, but always as an end"—which certainly look to the consequences of actions, and as we have seen, there is no logical support for any ready-made general rules of conduct. But the thought that the rightness of an action depends on the goodness of the motive which inspired it is not so easily refuted. Certainly, it is not reasonable to blame a man for acting in ignorance—not at least when it is judged that he could not have avoided his ignorance. We do not attribute blame to a man who with the best intentions in the world, as sometimes happens, sets in train a course of events with catastrophic results. Rather we say: "He acted for the best," and speak more in sorrow at undeserved suffering than in anger at unrighteousness.

From Kant we may deduce one or two important distinctions. Quite obviously the question of goodwill is important, and a man's will to do good or ill is an essential part of his moral character. But equally obviously it is impossible to secure a criterion of rightness or duty without considering the consequences of actions. The difficulty is resolved when we say that in judging the moral worth of a person the intention or will is the principal, and the chief logical basis of our judgment, but when judging an action we cannot avoid taking the consequences into account. In

other words, it is all a matter of precision—or recognizing precisely what is being judged and of judging it accordingly. But it is of absolutely vital importance that this distinction should be made and constantly borne in mind when moral praise or blame is being bestowed. Similarly, we must distinguish between what is thought right and what is right. We cannot blame a man for doing what he sincerely believes to be right, however mistaken we may judge his belief to be. But in society it may be necessary for the greatest good of the greatest number to restrain the individual from doing what he judges to be his duty, if his judgment is contrary to the accepted view of the right and the good. In general, it may be said that an action is right—that it ought to be done—if it leads to certain results which are judged to be good; but by contrast an individual must be judged to be moral and his actions must be judged to be moral actions, if he acts in accordance with what he believes to be his duty irrespective of the consequences.

Moral Sense Theory

We must regard two other theories, besides that of Kant, (see Fig. 9) which neglect the consequences of an action in considering its rightness or wrongness. One has been called the *moral sense* theory. It presupposes that we possess a moral sense which may be compared exactly with our other senses, those of smell, taste, etc. Just as we can distinguish with the sense of smell between pleasant and unpleasant odours, or with the sense of taste between sweet and bitter, so, it is suggested, we can distinguish with the moral sense between right and wrong actions. And, it is argued further, the possession of this additional sense is what distinguishes Man from the animal. Those men in whom the sense is highly developed are moral, those in whom it is relatively undeveloped tend to be immoral. Moreover, it is said, many known facts support the theory including the very important one that two different people frequently regard the same action as right and wrong respectively. It is just the same thing as when two people of different physical make-up find themselves in the same circumstances, and yet one feels hot and the other feels cold.

This is a very discerning theory, for it does, at first glance, explain a good many of the accepted facts of life, and it is certainly the first duty of a moral theory to explain the facts. But in refuting it, we must stress the point that it reduces the moral judgment to a mere feeling. Now we need not deny the value of feelings as such. It may even be true that the only things we really know are our own feelings. But there is a sharp distinction between a feeling and a judgment, and the rightness of an action is emphatically the object of judgment. Moreover, there is no physical or medical support for an organ of moral feeling as such, nothing to correspond for instance with the "backs" of the tongue in the case of taste or the olfactory nerves in the case of smell.

Therefore, the moral sense theory fails and must be discarded, but like most of the theories we have considered it contains an important element of truth. That is that many, perhaps all, of us are influenced by our feelings in making a moral judgment. We are revolted perhaps

at the sight of suffering and hasten to judge that it is wrong. As in the case of most other kinds of judgment we tend to make our moral judgments conform to our feelings. But so long as we distinguish between the two and make a genuine judgment, there is nothing illogical in that, nor does the fact lessen the reality or the objective nature of the moral judgment.

Intuitionism

The second theory which disregards the consequences of actions is the theory often known as *intuitionism*. It suggests that we recognize right and wrong solely by intuition—and that the resulting judgment is just as valid as the many judgments in other fields which are said to be made by intuition, for instance, that the shortest distance between any two points is a straight line joining them. As we have seen when considering Locke's refutation of the existence of innate ideas, there is some evidence that knowledge may be in part derived from "immediate" recognition of the truth without reference to experience. But it may well be asked: "What possible evidence is there that moral judgments which, if any, seem to depend partly on experience come into this category?" And the answer of course is: none. Again, if the moral judgment is objective and yet depends on intuition, it follows that each and every moral judgment is necessarily true—or else it has no objective value at all. Now if moral judgments as such were true, there would be no room for discrepancies as between the judgments of one man and another. Propositions such as the one we mentioned above that the shortest

Fig. 9. *Immanuel Kant (1724-1804).*

distance between two points is a straight line joining them may or may not be recognized by intuition —they are at least self-evident and do not admit of a difference of opinion. No one in his right mind would argue seriously that the shortest distance was anything but a straight line. But this is far from being the case with moral judgments, when one man can and frequently does argue vehemently against the judgment of another.

This particular theory is noticed only for the sake of completeness, and because it helps to demonstrate how difficult it is to distinguish between the three elements of an action—the motive, the act, and the consequence—and how impossible it is to judge an action right or wrong without taking into consideration more than one of these elements. At what point does an action end and its consequences begin? What of the small boy who shoots a catapult at a bird, misses the bird but hits a person who has just come round the corner and

whom the small boy had not seen—so that this person dies of shock? How distinguish between the act of shooting the catapult and the consequences? One cannot say simply that the person's death was a consequence, for it was clearly the consequence of many other facts in addition, such as the badness of the small boy's aim, the "accident" of the person coming round the corner at that moment, and the fact that he had a weak heart so that he died of shock instead of being merely bruised. And all these factors were the consequence of many other actions of which we cannot know. The main truth is that whilst we cannot foresee all the consequences, direct and indirect, of an action, it is quite impossible to dissociate the action from them. The three elements of an action, intention, act and consequence, are integral parts and must be considered together in any assessment of an action. One thing which follows from this conclusion is that no moral judgment is absolutely certain, because it may be said if we had been able to follow out all its indirect consequences we might have judged differently.

There is nothing here that need disturb us, for it is in the very nature of judgment itself to admit the possibility of a different interpretation. We do not, or ought not to, claim absolute finality for any judgment we make—only that it corresponds with the truth so far as we know it, and as far as we are able to assess the material facts.

Rashdall's Theory of Morals

These reflections bring us naturally to the theory of morals set forth by Hastings Rashdall, whose *Theory of Good and Evil* is one of the most complete and enlightened accounts of moral philosophy which have been written in modern times. Rashdall accepts some at least of the position of those philosophers who look to a basis of intuition for the moral judgment. He allows that moral judgment involves a judgment of value—and that this value may be judged without reference to the consequences or practical nature of the "good." Among the "goods" which are thus judged valuable, Rashdall places happiness (in this following the utilitarians), the good-will (in this following Kant), and a number of the recognized virtues which may be summed up in the word character. These, together with knowledge, culture, intellectual and æsthetic activity, are all elements of the goal which is a state of universal well being. Intuition is our guide not only in recognizing these elements of the good, but also in estimating their relative value. That is as much as this theory of morals permits to intuition.

Ideal Utilitarianism

In many respects Hastings Rashdall closely follows the utilitarian standpoint in holding that acts must be judged right or wrong according to their practical part in producing the state of well-being (or happiness or good) which is the rational aim of all action. It is in fact, a kind of "ideal utilitarianism" combining many of the truths derived from the theories we have been examining. "When morality, pleasure and other things are pronounced good, they must not be thought of as lying side by side without affecting or modifying one another; they are all parts, elements or aspects of an ideally good life which it is the duty of each to promote for all."

CHAPTER 7

MAIN CURRENTS IN WORLD HISTORY

Pattern of world history. Before the dawn of history. Stone ages. Discovery of metal. Genesis of civilization. Mesopotamia. Egypt. Mediterranean cities. Greek civilization. Roman civilization. Christ's teaching. Evolution of feudal Christendom. Towards the rising sun. Confucius and Buddha. Mohammed. The Crusades. Transition from the Old World to the New. The Renaissance. Evolution of modern Europe. Napoleonic wars. Beyond the seas. The British Commonwealth. The last phase. First World War. Russian Revolution. Second World War. The United Nations. Planning the future.

To present a coherent, intelligible, and worthwhile picture of world history in a single chapter, when volumes do not exhaust the life story of a single individual, is possible only if one accepts two assumptions. First, the primitive urges which prompt the greater part of human behaviour have changed but little through the ages, and in some respects not at all. Hunger and thirst, need for protection and for a mate, fear, jealousy. hatred, courage, sympathy, love, are not peculiar to any stage of human evolution, but are more deep-rooted than humanity itself. Equally universal and permanent is Man's dependence on the land and on work, though not necessarily his own. Moreover, further than the eye of history can reach, there were they who "carved the red deer and the bull upon the smooth-faced rocks"; there were, too, the relatively strong and the weak, the efficient and the inefficient, as there were men, women, and their dependent offspring.

The second assumption is that the history of human development is not a haphazard, capricious story of unrelated incidents, but a rational account of causally related events. However complex may be the story, it is one of a consistent development along lines which stand out as clearly as those which give formal pattern and coherence to a picture or to a symphony. There is, therefore, neither interest nor value in any study of history which fails to reduce to some orderly unity the vast complexity of human actions, or which forgets that it is the study of humanity. It becomes of value, for example, if it reminds us that, while men are sufficiently alike to make their general behaviour intelligible, they are sufficiently different, individually, to make necessary the organization of justice, and desirable the practice of mercy.

In the pattern which human destiny has been so long weaving, a number of threads stand out, clear to the most unobservant eye. The source of all human wealth is the land, and, in turning to it for the materials for the satisfaction of all his needs and desires, Man

had first to be satisfied with the little world of his immediate environment. As he has learned to move farther and faster than his own legs would carry him he has extended the area of land which ministers to him, and therefore the variety of his wealth, by settlement, migration, conquest, trade, exploitation and other means, until, in the unequal race, some peoples draw their wealth from the whole Earth.

Moreover, the land yields its wealth only in return for labour—someone's labour. As it is obviously desirable that one should have sufficient leisure to do more with life than the necessary work of keeping oneself alive, and as this necessary work has increased in proportion to the increasing complexity of society, so there has been throughout history a consistent delegation and specialization of necessary labour. The nomadic patriarch kept in stern subjection his wives and families, for their labour gave him the luxury of leisure. The peoples of the ancient civilizations solved the problem by slavery; the feudal peasants, under a land-holding aristocracy, had but little distance to sink into a state of serfdom, from which in Russia they were not freed until 1861. Negro slaves provided the labour for the cotton and sugar plantations, and traffic in this human produce brought profits to the European merchants who bought and sold the Negroes. The commercialization of society based on a capitalist economy has produced a working class dependent on its capacity to find wage-paying work, and the paradox that unemployment is something to be cured.

If there were nothing to add to this grim record of the age-old struggle for power, wealth, and similar material ends the story would hardly be worth the telling. But always it is possible to discern, even in the darkest ages, a struggling idealism, a conception of responsibility, of moral goodness. Sometimes it is but a flickering spark; sometimes no more than a smouldering ember, to be fanned again into life, as with the teaching of Buddha, flaring into fullness with the teaching of Christ, and kept alive by all the unnoticed acts of unselfishness or, though the truth is less obvious, by Man's persistent love of beauty and the arts. Let the poetry and music in life be destroyed, let the tiny spark of moral goodness be laughed out of court, let such doctrines as that of Walpole, that "every man has his price," gain currency, as they threaten to do today, then men sink lower than the brutes, and know no god but Fear.

Before the Dawn of History

Even a million years are but a small fraction of time in the story of the evolution of the Earth or even in that of the evolution of life on the Earth, yet half this time is enough to cover practically all that is known of the evolution of Man from the more or less human creatures who, even in so remote an age, were sharing with the beasts the hard task of living. During the last six hundred thousand years or so, for four long and varying periods, the North Polar ice cap has extended far to the south, turning great areas of land into barren wastes. After reaching a period of maximum cold the Earth's climate would gradually warm again, changing unnoticeably over thousands of years. The area of

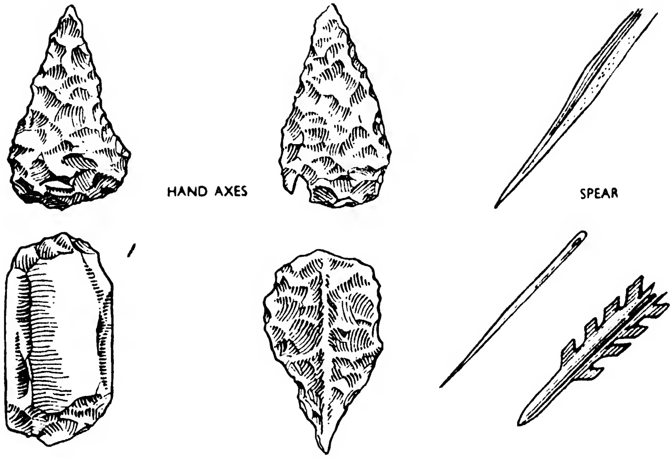


Fig. 1. *Tools and weapons of the Early Palæolithic Age and (below) Later Palæolithic Age, made of either bone or stone.*

permanent ice would shrink imperceptibly towards the north, in our hemisphere; accumulated masses of melting snow and ice would flood the valleys and plains, leaving lakes in the mountain hollows and swelling the rivers, which would deposit sand, silt, and other debris in fertile layers many feet deep. Gradually an Interglacial Age would develop; vegetation would appear where before had been deserts of ice; forests and grass-land would replace a wilderness of steppe; and, farther to the south, hot arid deserts would appear where before there had been vegetation. Arctic animals drifted northwards, to be followed by other animals and by Man.

It is neither necessary nor, in the space of this chapter, possible to attempt to unravel the conflicting story of human life before the last of these four Ice Ages, the glacial period which lasted, if we include a period of slow transition into the present conditions, from about 50,000 to 10,000 B.C. While there is evidence that there were true men as far north as the Thames Valley even in the second interglacial period, about two or three hundred thousand years ago, there is also evidence that a much more sub-human and ape-like type was living in northern Europe as relatively recently as sixty thousand years ago. What is certain, however, is that men still relied on crude stone weapons and tools of bone even fifteen or twenty thousand years ago.

The Stone Ages

Imagination and the still scanty but growing evidence unearthed from the deposits of centuries tell us something of the lives and even of the appearance of these men of the Later Palæolithic or Old Stone Age (*palaios* means "old," *lithos* means "stone"), of these cave-

dwellers who were both hunters and hunted, and who shared life with the mammoth, the woolly rhinoceros, the wild boar and the bison, with the bear, and other creatures, some more, some less formidable. The human cave-home, like the den of the wild animals, would be littered with the remains of many meals, and the bones of animals slain; scattered about would be implements and weapons of flint, bone needles, scrapers, axes, and drying skins (see Fig. 1). Where conditions were not too severe there was some leisure, as is shown by the astonishing drawings and paintings left on ivory, bone, and cave-wall. That there were fires is known, and, because of the difficulty of lighting them, it is probable that such fires, useful for protection and for the scorching or grilling of meat (for there were no cooking utensils), were seldom allowed to go out. There must have been artificial light, probably lamps of hollowed stone, for pictures were drawn and painted in the dark interiors of the caves. Primitive no doubt they were, these hunters of wild beasts and gatherers of the wild fruits; but they had courage and resource. Yet they never learned to domesticate any animals, or to cultivate grain, or to use timber for dwellings or even for the shafts of their flint axes. They had no buildings, no pottery, and knew nothing of the use of metals.

While in northern Europe this Palæolithic stage of human development persisted, men farther to the south where life was easier had reached the Neolithic or New Stone stage, in which very revolutionary contributions were made to human progress. Moving northwards in the wake of the retreating ice, the Neolithic Men were spreading into Europe about 12,000 B.C., reaching Britain about 5,000 B.C. The same stage had been reached in the fertile valleys of Mesopotamia and Egypt probably as long ago as 18,000 or even 20,000 B.C. It was during this period of Neolithic development in Europe that forests were slowly replacing the wilderness of steppe, that giant oxen, lions, deer, goats, sheep, and other animals which had kept to the warmer south, were replacing the Arctic animals, and that northern Europe was opening to human occupation. While men in Europe and Asia were, in general, moving northwards, the general movement in America seems to have been southwards, as men were pushed across the land which then spanned the Bering Strait.

The most revolutionary contribution which Neolithic men made to human progress was the invention of farming, for they learned both to domesticate animals and to cultivate crops. Both processes are essentially similar, for, instead of searching out the wild animal or fruit, men brought both into their protection, fostered their nourishment and periodic reproduction, and thereby secured their own food supply. The change, however gradual, from a life dependent on hunting to one which included farming, however primitive, implied a social and economic revolution in men's lives, for it necessitated some form of settled and communal life; from this necessity there developed the village community.

Raids on the cattle and sheep and crops which constituted property and wealth must have been common —they survive in modern warfare— and Neolithic Man seems to have lived in constant fear of being

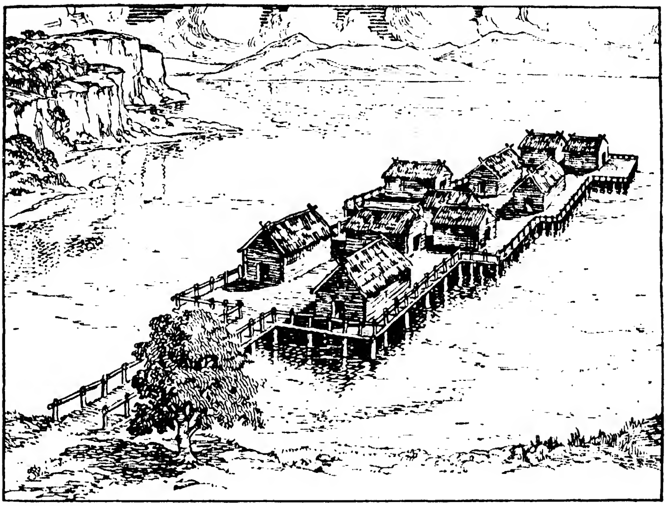


Fig. 2. *Village of Neolithic lake dwellings, built over the water as a protection against surprise attacks by robbers.*

robbed of his possessions. It is for this reason, probably, that he seems to have preferred to live, when it was possible, on the open moorlands, even though this meant poor pasturage and scarcity of water.

Neolithic Village Life

The typical home of Neolithic Man was simple, often consisting of a scooped-out hollow surrounded with the excavated soil, and covered by a roof of bracken-covered branches supported by a central pole. The typical village, where such conditions were possible, would consist of a number of such crude dwellings, surrounded by a palisade or ditch, behind which the cattle and sheep would be withdrawn in the event of a raid. Another form of Neolithic village, of which remains have been found in Switzerland, Scotland, and Glastonbury in Somersetshire, and which survived in Ireland until the sixteenth century and exist today in some Pacific Islands, was the community of lake dwellings (see Fig. 2).

The development of primitive farming demanded also organized and systematic labour, both for the women and the men. Animals had to be fed and protected, crops had to be planted, tended and harvested. An increase in material wealth such as is implied in the availability of milk and, when the process of making them was discovered, of butter and cheese, was the reward of so much additional and regular work. Fences had to be kept in repair, clothing had to be made, water had to be carried and stored, and a constant look-out had to be maintained against attack. It is well to recall that as yet such people

knew nothing of metals, and had to rely on their weapons and tools of polished flint, bone, horn and the like (see Fig. 3).

Even at this stage, however, the crafts of spinning and weaving were known and practised. The spinning was done by means of spinning whorls, which were simply weights of stone, bone, or baked clay. The art of pottery had been discovered, and many fragments of earthenware vessels survive. For lamps they used shallow vessels of stone filled with oil or fat.

Social Differentiation

A group of factors which make the Neolithic stage of human progress one of outstanding importance in human history, were those involved in the specialization, control, and organization of human behaviour necessitated by the development of a settled communal life. Human differences in intelligence, cunning, strength, imagination, and so on, in any community where there is a multiplication of labours and where there are possessions, must lead to social and economic differentiation. In many parts of Europe, including Britain, Neolithic Man mined his flints. The blocks were then taken to skilled flint-smiths who seem to have followed a highly specialized craft. The extent to which the products of the flint industry were bartered for food or other necessities or how they were distributed can only be conjectured, but it is certain that there can be no specialization of any kind without some system of exchange and without, as a consequence, some differentiation of wealth.

A more important specialist was the priest. From the human sacrifice which frequently accompanied the primitive sowing to the modern harvest festival, there has been an almost universal tendency to recognize, both in the fruition of crops, and in their occasional destruction through storm or drought, a creative and a destructive agency of omnipotent capacity, and to seek its aid or appease its wrath by some religious ceremony. An interesting and imaginative speculation as to the origin and development of this association is to be found in Sir J. G. Frazer's *Golden Bough*. Certain it is that in this stage of human progress the priests, as the representatives and instruments of whatever gods had been conceived, gained vast power and authority. In those regions where communal life was necessarily more highly concentrated, as in the narrow valleys of the Nile, the Tigris and the Euphrates, the priests tended to become the centres of authority in the several communities. Where communal life was more diffused, as in Britain, the priests, still all-powerful, tended to become an external and separate organization, while the control of individual communities passed into the hands of anyone strong enough to seize it and to retain it.

Thus, in these prehistoric days, were laid the foundations of organized and disciplined communal life, with its specialized crafts and craftsmen, its increased control of natural resources to an increasingly varied human use, its increased orderliness and progressing form of government through priest or other authority, its developing social differentiation, and the consciousness of a communal responsibility which the common dependence on crops and animals

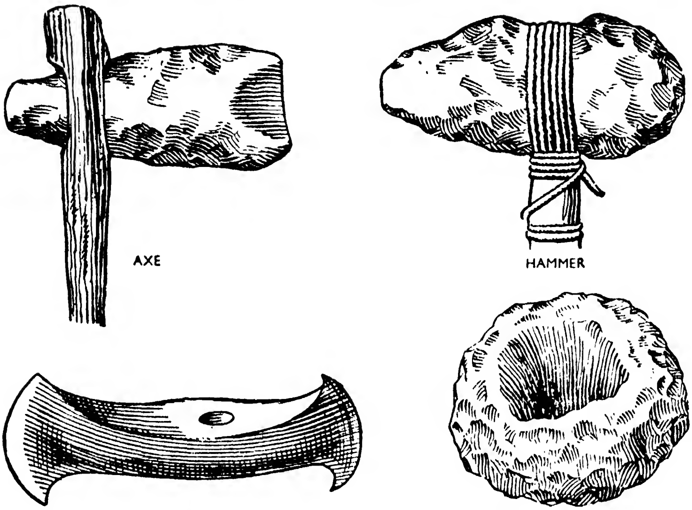


Fig. 3. *Implements made by Neolithic Man. Note the elaborate shaping of the pierced axe, made from polished flint.*

and a common fear of attack must have developed. One of the most interesting qualities of Neolithic Man is his changed attitude to art, for which he, like his Palæolithic predecessor, found time in spite of his greater labours. Whereas the art of the Old-Stone Men was pictorial and representational, that of the New-Stone Men was essentially decorative. Simple geometrical patterns, still to be seen on relics of his pottery, pleased him, and the fine finish of some of his flint products shows his delight in good craftsmanship. The artisan was evolving into the artist.

Discovery of Metals

The long Stone Ages which had persisted for hundreds of thousands of years came to an end with the discovery of metals. As men in the warmer regions of the eastern Mediterranean were entering on the agricultural stage while the Old-Stone Men of Europe still hunted in order to live, so the use of bronze was known in Mesopotamia at least 6,000 B.C., while knowledge of it was spreading slowly through Europe from about 4,000 to 2,500 B.C. In Australasia the Stone Age lasted until about a hundred and fifty years ago.

The discovery of metals was revolutionary not only in that it provided far more efficient tools and weapons than those of stone (see Fig. 4). The relative rarity of metal and the additional value it gained through skilled craftsmanship, together with its peculiar attractiveness, gave to it a value beyond anything previously known to Man. Moreover, its relative rarity and value implied, in its possession, a still greater and more obvious social

distinction than had before existed. Lands where there were supplies of the copper and tin of which bronze is an alloy had to be found, and the need led to exploration and to trade, to settlements, conquest, and the general extension of Man's world.

We have already observed that human progress was most rapid in the most favoured lands, particularly those of Egypt and Mesopotamia, that knowledge and progress spread thence slowly throughout Europe, while the peoples of more remote lands remained almost at the Palæolithic level until, in modern times, Europeans have reached them. There were, of course, other favoured centres of development, but, in the space of a single chapter, it is convenient to leave them until the moment when their discovery by European peoples brought them into the world arena.

The Sumerians

There are many reasons why the earliest and most rapid human progress, and particularly the growth of village settlements into cities, should have occurred in Mesopotamia and Egypt (see Fig. 6). The periodic fluctuations of world climate which, during the period of human evolution, had four times made vast areas of the northern continents uninhabitable and made the task of living difficult in still greater regions, had added to the human value of the valleys of the Tigris, the Euphrates, and the Nile. Not only were these valleys continuously fertile; during the interglacial periods the neighbouring lands became increasingly arid desert. Thus, life in the valleys was continuous and concentrated, but it was liable to frequent intrusion by peoples from nearby and less favoured lands. While defence was, therefore, always necessary, it was made difficult by the fact that the settlements, particularly in Egypt, were inevitably spread in a long, thin line along the valley. The more favourably situated village communities, therefore, were bound to develop into the larger, fortified strongholds which became walled cities. In such cities all the factors we have observed as being characteristic of settled communal life were accentuated. Moreover, the nature of their origin made them jealously independent, so that each tended to develop as a city-state, an organized unity controlled from within. The social opportunities and obligations characteristic of city life are the parents of civilization.

From about 8,000 to 6,000 B.C. the peoples of the land between the lower valleys of the Tigris and Euphrates, the people known as Sumerians, were passing from the village to the city stage. Villages of reed huts in that marshy land were changing to collections of mud-brick dwellings round a sacred shrine where a temple of sun-baked clay would add to the dignity and authority of the ruling priest. Thus grew the city of Nippur, one of the earliest of them, round the temple of En-lil, god of the storm-demons. Other Sumerian cities grew at Erech and at Ur, "Ur of the Chaldees," where Nanna the moon-god was worshipped. In the streets would be seen asses and cattle, and here and there men would be bartering their goods. Food there would be in plenty, in this fertile land where the date palm and the fig tree grew. They had, too, gold, silver, and bronze and woven cloths, though not of silk.

Thus the cities grew, and with

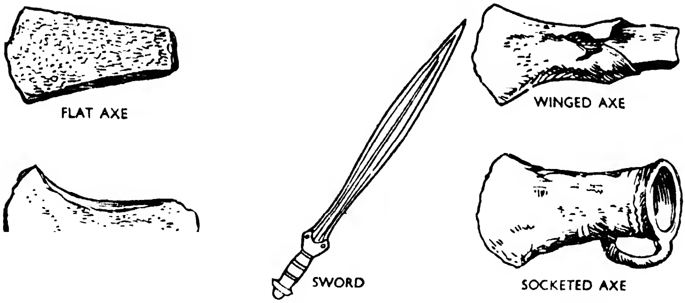


Fig. 4. *Bronze Age tools and weapons. The metal was smelted in furnaces which were very similar in appearance to the American-Indian beehive ovens.*

their growth society became more complex, authority more rigid, the rich and the poor more widely separated. More and more powerful rulers and officers, religious, civil and military, more and more specialized craftsmen, masons, metalworkers, weavers, potters, and the like, with musicians and other artists, all added to the number of the city's specialists and all these had to be fed and clothed. As each city had evolved from a self-supporting agricultural community, and as each city remained essentially an economically and politically independent unit, the inevitable solution of its labour problem was slavery. Conquered foes provided an obvious source of labour, but the degradation of a peasantry into a state of servitude has always been an easy tendency.

History, in so far as it depends on the written record, begins with the evolution of a written language by the peoples of these ancient cities. Passing from the stage of direct pictorial representation to that of symbols, firstly of things and then of sounds, an intelligible written record slowly evolved. When a stage is reached in which the symbols are not directly intelligible to the uninitiated, they have to become fixed and learned. The Sumerians made their marks with a sharp-pointed wooden instrument on soft clay, which was afterwards baked hard, to form an unusually permanent record. The wedge-shaped marks form what is known as cuneiform writing (*cuneus* means "a wedge"), an example of which is seen at the foot of the Assyrian bas-relief shown in Fig. 7. With the development of writing, tradition passed into law, authority could be carried farther afield, contracts could be recorded, and the knowledge gained in one generation could be conserved for the next.

Egyptian Civilization

While these developments were taking place in Lower Mesopotamia an almost parallel civilization was evolving in the Nile Valley. The earliest of the Egyptian cities was Memphis, on the Nile's west bank, fourteen miles south of modern Cairo. With two exceptions, one important and one less significant, all that has been said of the developing civilization of the Sumerians can be said of that of the

Egyptians. The first difference is due to the dependence of the Egyptians for the fertility of their land on the annual flooding of the Nile when the snows of the Abyssinian mountains melt. The Egyptians had long discovered how to make the greatest use of the floods by diverting some of the water through channels or canals into the fields. The danger of uncontrolled interference, whereby dwellers in the upper valley might deprive those of the lower valley of their water supply, necessitated a more widespread control in Egypt than was demanded in Sumeria. Thus, while the Sumerian cities remained independent city-states under their own priestly rulers, there arose in Egypt the supreme god-king, the pharaoh. After a long struggle Egypt was united under the control of a single pharaoh, Menes, in 3,500 B.C.

The second difference is that Egyptian writing, though it passed through similar stages of evolution, was painted on strips of papyrus, a reed from the name of which the word paper is derived. The Egyptian symbols, and hence similar ones (see Fig. 5), were later known as hieroglyphs or sacred symbols. Thus, in Sumeria and Egypt, from approximately 4,000 B.C., history has its records. The first fixed date, the beginning of the Egyptian calendar, is 4,241 B.C.

For some thousand years or so after the union of Egypt, its cities and those of Sumeria continued to grow in size and in splendour. Already old was the Great Pyramid which had been built in 3,700 B.C. as a tomb for the pharaoh Khufu (or Cheops) and his queen by hundreds of slaves compelled without mercy to raise the massive slabs four hundred and fifty feet. Two other pyramids were built nearby. Ur eventually grew into a city of two hundred and twenty acres.

The Semitic Peoples

Meanwhile, outside the confines of these growing civilizations, there were peoples still living a nomadic life. On the steppes and grasslands of Asia were the Mongolian horse-riders, the Huns; nearer were the Semitic shepherds of the oases. Though life was harder for these peoples than for those of the settled communities, it had compensations. There were less inequality and greater freedom, more independence and no slavery. Such people were hard because their life was hard, and it was from the desert nomads that the peoples of Egypt and Sumeria had most to fear. Necessity had long taught them to organize raids on the settled communities, and the transition from raiding to conquest is but a matter of relative efficiency. About 2,750 B.C. one of the Semitic leaders, Sargon, conquered the Sumerian peoples and made himself master of the land from the Persian Gulf to the Mediterranean. Though his empire was short-lived, the possibility of Semitic conquest had been demonstrated, and, after establishing themselves in the little town of Babylon, the Amorites, another Semitic tribe, rapidly dominated the whole of Sumeria. About 2,100 B.C. the Babylonian Empire, thus founded, was consolidated by Hammurabi, the "Great Sun God," who gave his empire a code of laws which were engraven on pillars of stone, set up in different parts of his dominions.

Similar conquest brought Egypt, from about 2,000 to 1,600 B.C.,

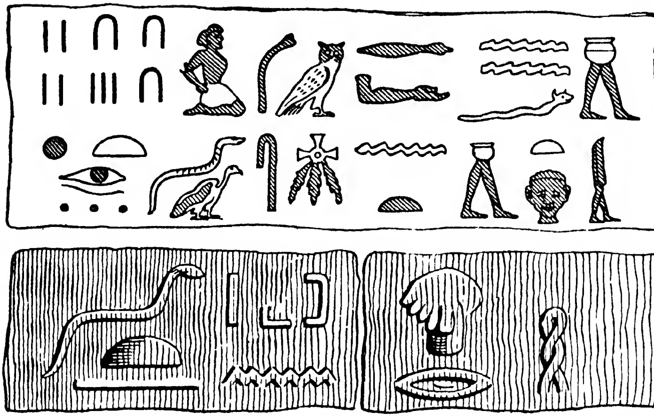


Fig. 5. *Egyptian hieroglyphic writing, the symbols of which were developed from picture writing. Above: painted on papyrus, and (below) carved.*

under the rule of the Hyksos or Shepherd Kings; but, whereas Babylonia remained Semitic, Egypt drove out the invaders.

Other city-states had already begun to spread a similar civilization "into the regions round about." In the sheltered islands of the Ægean one such civilization, with its centre in the great palace-city of Cnossos in Crete, was as old as that of Egypt, while on the contiguous mainlands of the Balkans and Asia Minor other cities, such as Mycenæ and Troy, flourished. A Semitic people, the Phœnicians, had developed from desert traders into sea traders, and many of the trading depots they established on the Mediterranean coast were developing into wealthy cities. Such were Tyre, Sidon, Acre, and Beirut, in Syria, and, destined to be the greatest of them, Carthage on the African coast. Another Semitic civilization, that of the Hebrews, was developing in Judah round the city of Jerusalem, while farther to the east, yet another, that of the Assyrians, had its nucleus at the city of Nineveh on the eastern bank of the upper Tigris (see Fig. 6).

The Power of Egypt

It was unlikely that these contiguous civilizations should have continued to develop peacefully, and the period approximately from 1,600 to 600 B.C. is one of war and conquest, though it is also one of great material development. After the expulsion of the Hyksos, Egypt began a career of conquest, using for the first time horses and horse-chariots. Tethmosis III, pharaoh from 1,501 to 1,447, carried his conquests through Syria into Babylonia, and used his captive slaves, plunder and tribute to add to the splendour of Egypt. There is no space to tell of the deeds of Amenophis II, who sacrificed seven captive kings to the god Ammon; of the might of Amenophis III, whose empire spread from Libya to the Euphrates; of the reforms of Amenhotep IV;

of the great temple of Karnak, completed by Rameses II, in whose reign, it is said, Moses led the Israelites from captivity; or of the general splendour of Egypt when it was at the height of its power.

Assyrian Conquests

Already the Assyrians were becoming a formidable military power, and in the thirteenth century B.C. were temporary masters of Babylonia. A second Assyrian Empire was founded in the eighth century B.C. by Tiglath-Pileser III, and for the first time outlying conquered provinces were organized under a central authority which wrung tribute, goods, and soldiers from them. Assur-bani-pal carried Assyrian conquests even into Egypt, and was "King of all the Peoples from the Sea of the Rising Sun to the Sea of the Setting Sun," from the Persian Gulf to the Mediterranean. Great palaces and temples, magnificent sculpture, picture records of victories and imperial tyranny (see Fig. 7), and a general luxury, characterized the period of Assyrian greatness as it did that of Egypt. But the long story was fast coming to an end. A different and a harder people were already hammering at the frontiers of the Semitic empire, helped by the internal rottenness of a structure dependent on fear and force for its maintenance. In 606 B.C. a people from the north, aided by the Babylonians, attacked Assyria, and left of the proud city of Nineveh only a crumbled ruin.

The Aryan-speaking Peoples

Beyond the physical barrier of mountain, marshland, and internal seas which fairly effectively isolated the Semitic and allied civilizations, there wandered about Europe and south-west Asia a people who, by

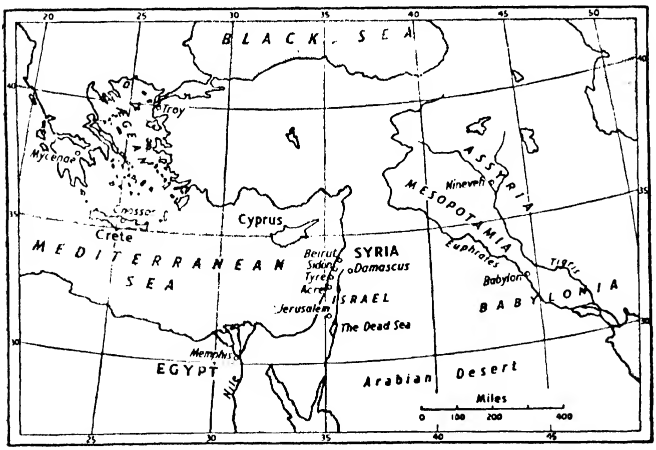


Fig. 6. *The cradle of civilization. Map showing the many city-states that grew up in the region of Mesopotamia and the Eastern Mediterranean. The Phœnician traders also founded a large city farther west, at Carthage.*

Fig. 7. *Assyrian bas-relief showing vassals bringing tribute. Note the cuneiform characters at the foot.*

no means racially pure, differed from the Semitic and Mediterranean peoples. Moreover, they spoke languages which had a sufficient number of common words and roots to suggest an original common language. They are, therefore, known as Aryan-speaking peoples, or, more conveniently if less accurately, Aryans. Fair and blue-eyed, these Nordic peoples combined temporary settlement and primitive ox-ploughing with a semi-nomadic life, moving from one forest clearing or open grassland to another when they had exhausted it, or tired of it, or were driven from it. They knew the use of bronze and were possibly the first people to discover the smelting of iron. It is in the lives of these peoples that is to be found much that was to characterize European development for centuries to come.

In their essentially rural and open-air life it was the chieftain rather than the priest who became the leader of men. They knew no form of writing, but developed in song and saga their legends and the story of their exploits. It was they who, known as Gaels or Goidel Celts, carrying weapons of bronze, conquered and settled in Neolithic Britain. Later the Brythonic Celts, probably with iron weapons, conquered Britain in their turn. Other Aryans penetrated into Spain and Italy, others into the Balkans, others again into India. The Balkan invaders were the Greeks. By about 1,000 B.C. they had destroyed the Ægean civilization and settled on its ruins (see Fig. 8). Similar Aryan-speaking peoples were already threatening Assyria and Babylon. It was they, the Medes and the Persians, who with Semitic allies, destroyed Nineveh.

The Persian Empire

Babylon was rewarded for her contribution to the overthrow of Assyria by the reviving of her empire which, under Nebuchadnezzar, reached its greatest splendour, and stretched from Egypt to the Persian Gulf. To the north lay the empire of the Medes, spread to the frontier of India. The two empires, the Semitic and the Aryan, existed peacefully enough until 538 B.C. when Cyrus the Persian, ruler of the northern empire, entered Babylon, as the Bible tells, and united the two empires. Under

Darius the Mede this vast Aryan empire, the greatest the world had yet known, included Egypt, Asia Minor, Syria, and all the land eastwards to India. Roads were built, one from Susa the capital to Sardis 1,600 miles long. Along them horses, soldiers, traders, messengers, and others helped to bring a sense of unity into the empire.

There were great differences between the new Aryan type of empire or even of settlement and that of the ancient civilizations. The old ones had grown slowly and inevitably out of the conditions which gave them birth. The new ones were imposed on the ruins of the old. The Aryans entered on their inheritance with an ingrained sense of freedom and independence; they had no awe of priesthood, and the mysticism of ritual meant nothing to them. They were not deadened by long subordination to tyrannous rule or softened by luxury. With their coming, a breath of fresh air blew through the stuffy palaces and mystic temples.

The Greek Civilization

It was amongst the Greeks that this freedom, this independence of thought and rational simplicity, found through the influence of the physical factors of environment the most perfect expression, and whence it was to have the greatest effect on subsequent human development.

Probably from about 3,000 B.C. there had been a slow infiltration of Greek tribes into the Balkans. By 1,300 B.C. the whole peninsula was Greek-speaking. The great epics, the *Iliad* and the *Odyssey*, which had probably existed as oral legends long before they were written in the eighth or seventh century B.C. (whether by Homer or not is of little consequence) tell of the heroic days of conquest, when the Mycenæan Empire was being overrun by heroes, of the fall of Troy, and of the adventures of Odysseus. They tell of the early lives of the conquerors, still semi-barbaric, living, as did the English later when they conquered Roman Britain, in open villages outside the ruins of the towns they had destroyed. They tell, too, of the chieftains who had led them into battle and who, afterwards, ruled the settled tribes as kings. Already there was a Council of Elders, or perhaps of favoured retainers, but the whole body of freemen could be summoned by the king either to fight or "to hear and acclaim" his decrees. There is a familiar quality about this triple organism of king, noble council, and general assembly.

Greece is a land of mountains and valleys, a land into which the sea makes long inroads, a land therefore in which settlements tended to be relatively isolated. During the period of the tribal monarchies the various settlements began to crystallize into small city-states, of which only one, Athens, ever had a population of over fifty thousand, and each of which tended to develop in its own characteristic way. During the centuries of Greek development no monarch ever united into a single entity the separate city communities. What sense of unity existed was derived from common traditions kept alive in their poetry, or from their general participation in the Olympic Games.

With the development of city life, as at Sparta, Athens, Corinth,

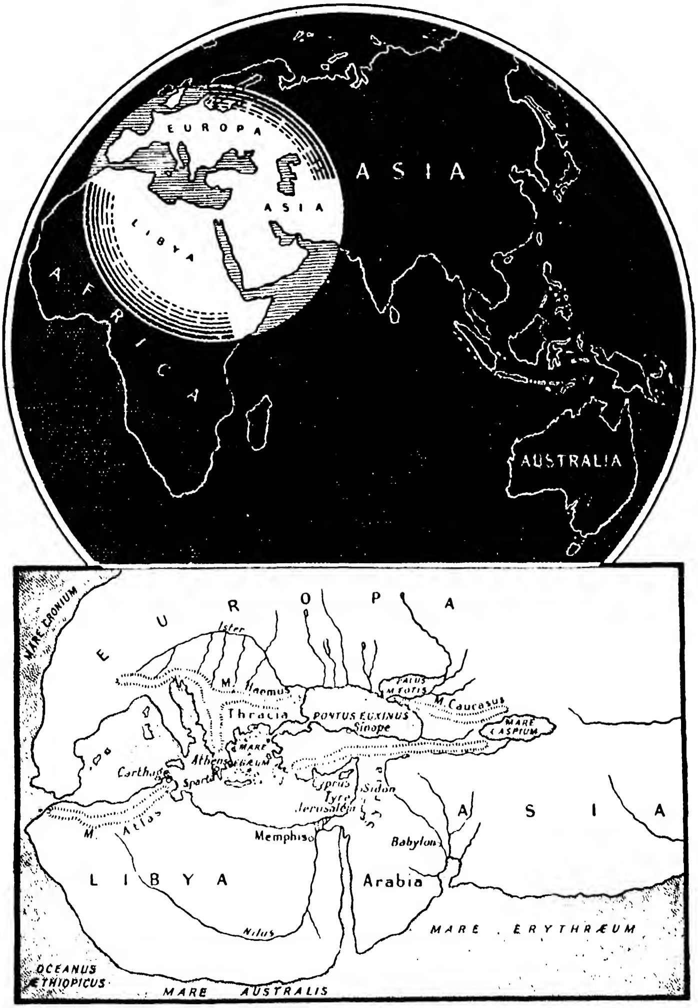


Fig. 8. *Maps of the world as it was known to the Greeks in about 450* B.C.

Thebes, Samos, Miletus, or Argos, tribal kingship ended, to be followed by a period of aristocratic rule during which, in each city, some form of political machinery was evolved; sea trading developed, and colonies were planted, to grow into Greek cities on Mediterranean

coasts. Southern Italy became known as Magna Graecia; other colonies were settled in Sicily, in Asia Minor, and one Greek city was founded as far west as Marseilles in South France.

Constitutions of Sparta and Attica

The individual nature of the development of the Greek cities is well illustrated by the constitution of Sparta. Developed from the union of five villages and probably from that of two tribes, Sparta had two kings. This division of authority rendered monarchy sufficiently innocuous to provide an explanation of its retention in Sparta. The second peculiarity of her constitution was that, in addition to the retention of the Council and Assembly from ancient times, there were the five Ephors, elected annually by lot from the whole body of citizens, and invested, as guardians of the rights of the people, with the authority to summon even the kings to appear before them. Thus the Spartan constitution was at once monarchic, aristocratic, bureaucratic, and democratic!

The main characteristic of Spartan life, was that the life of every man, woman, and child was controlled from birth to death by a rigid system of disciplinary training directed towards the perfection of the city as a fighting unit. Weakly infants were slain; the strong, from the age of seven to that of twenty, were trained and disciplined at military schools. From twenty to thirty they undertook military service, and though permitted to marry, were not allowed home life. Full citizens at thirty, the men, relieved of the necessity of providing for their families by a controlled distribution of produce, continued to devote their lives wholly to the service of the city-state. This Spartan conception of communal life has not been forgotten. Its origin was attributed to Lycurgus, who was supposed to have lived in the ninth century B.C., but who was probably a mythical figure. A similar conception existed in Crete.

Before the days of history the peoples of the little peninsula of Attica had been united, and Athens had arisen as the central city of a united state of which every citizen, whether of an Attic village or of Athens itself, had equal rights. By the seventh century B.C. aristocratic rule had replaced that of monarchy, and the free population was already differentiated into nobles, peasants, merchants, craftsmen and the like.

The introduction of money into Athenian life, as elsewhere, intensified social distinctions and, as money was for a long time scarce, made life particularly difficult for the small peasant proprietor. As the penalty for unrepayable debt was the enslavement of the debtor to his creditor, peasants, who were forced to borrow to live, first sank into a landless class and then into servitude. A written codification of the law by Dracon, 621 B.C., did little more than expose its severity, and distress and agitation were such that in 594 B.C. Solon, a wise, popular, and wealthy merchant of noble family, was asked to undertake the social reformation of Athens. Debts which pledged the person of the debtor were annulled and men enslaved through debt were freed; no further enslavement through debt was to be possible; the size of estates was restricted, and the exportation of necessary foods was forbidden. Solon,

moreover, laid the foundations of Athenian democracy by the constitution of courts of justice of which the judges were elected by lot from the whole body of citizens.

A century later the work was completed by Cleisthenes (508 B.C.). His reformed Athenian Council, which was in effect the governing body of the state, was a popular representative assembly, in which Attica's reformed electorates were proportionately represented, and from which various administrative committees were chosen.

Thus in Sparta are to be found the germs of that form of state organization in which all service is subordinated to the will and efficiency of the state. In Athens is to be found the germ of that view which regards the state as an organization which exists for the expression and execution of the popular will.

Greek Culture

Except when called upon for obligatory political service (*polis* means "a city") the Greek citizen had a life of leisure, for all necessary and burdensome work was done by slaves."A life of leisure, by men too intelligent to be idle, in a small community where mischief was dangerous, where stupid behaviour was despised and arrogance ridiculed, where life was simple, healthy, and sincere," was bound to produce the great works of philosophy and art which characterized Greek life at its best. A love of wisdom, a joy in intellectual thought and discussion, a conception of ultimate values, of truth, of beauty, of goodness, of ultimate purpose, the value of pure reason, such were amongst the contributions which Greek life made to humanity, though, as ever, they co-existed with the greed, selfishness, superstition, ignorance, and general materialism, which were to be found even in Athens, and though the conditions which helped their development depended on slavery.

Meanwhile, the conquering Persians were drawing dangerously near, and the empire of Darius, which we have already observed, was threatening the Greek colonies of Asia Minor. Their refusal to pay tribute determined Darius to conquer the Greeks. Within the Aryan framework Semitic financiers and traders continued to flourish, and their jealousy of the growing sea-power of the Greeks made the Phœnician fleet available to Darius. The islands of the Ægean were rapidly overrun and, in 490 B.C., a Persian army landed at Marathon—and was defeated. Ten years later a second Persian army, led by Darius's son and successor, Xerxes, landed at Salamis. A small force under the Spartan Leonidas was slain to a man at Thermopylæ; Thebes surrendered; Athens was burnt. But, at Salamis, a small Greek fleet fought and destroyed the Persian fleet. A remnant of the vast Persian army reached Asia Minor, and Greece was saved.

Though the jealousies of the Greek cities drove them into internecine struggles and made them a prey, in the fourth century B.C., to Macedonian conquest, the century following the defeat of the Persians was Greece's Golden Age, particularly in Athens, which Pericles rebuilt. Scholars, artists, poets, philosophers, dramatists, architects, and teachers settled in the city Amongst them Socrates (*c*. 470-39

B.C.) was so disturbing the placid acceptance of the obvious by his questions and by his teaching men to think and to reason that he was condemned to drink poison. But the work was continued, first by Plato (*c.* 428-348 B.C.) and later by his pupil Aristotle (384-322 B.C.), who laid the foundation of scientific reasoning, and who brought the study of philosophy and the science of logic to a height that was not equalled until modern times.

The Macedonian Empire

Though the influence of Greek life and thought was to endure, the Greek Age was over. To the north of the Balkans the Aryan-speaking settlers had been welded into the kingdom of Macedonia. Aristotle was the son of the physician of Macedonia's king, Philip, and tutor to Philip's son, Alexander. Philip, though he admired the art and learning of the Greeks, despised their endless struggles, and with little difficulty added their states to his dominions. He then determined on the conquest of the Persian Empire, but was stabbed before he could set out. The task fell to Alexander. In less than twelve years Alexander's empire included all the lands from the Balkans to the frontier of India.

Though the empire was divided at his death Alexander had been more than a mere conqueror. Greek scholars were introduced into the lands he conquered, and in Egypt, Alexandria, which he founded, became a centre of Greek culture long after Greece had ceased to flourish. To its great library scholars from all lands where learning was valued flocked for discussion or knowledge. There, in the third century B.C. Euclid founded the science of deductive geometry; Archimedes (287-212 B.C.) developed the study of physics; in the third century A.D. Plotinus, of Alexandria, was teaching Greek philosophy to the Romans.

The Growth of Rome

The Italian peninsula, forested, mountainous, poor, had not attracted Phœnician traders. A Semitic people known as Etruscans had settled in the centre and north-west (see Fig. 9); there were Greek colonies in Sicily and the south; and over the rest were the scattered tribal communities of the Aryan-speaking peoples who had filtered into the peninsula from the north, to eke out a poor existence by primitive farming. Seventeen miles from the mouth of the Tiber, where the muddy, yellow river could be forded, men had used to meet from the north and south to exchange their corn, oil, cattle, or other goods. The dwellers on the neighbouring seven hills had learned to profit by guarding the ford and demanding toll. Thus grew the market village which was to develop in time into the city of Rome, the city destined to play so great a part in human lives.

When history begins Rome was a city in the hands of the Etruscans. In about 510 B.C. the Romans drove out the Etruscans, took over the city, and organized it as a republic under the military rule of two officers known as consuls. For over a century the Romans had to struggle against the Etruscans, while within the city the plebeians, or ordinary citizens, were striving to deprive the aristocratic patrician families of the privileges they were equally determined to retain. In 474 B.C. the Etruscan fleet was

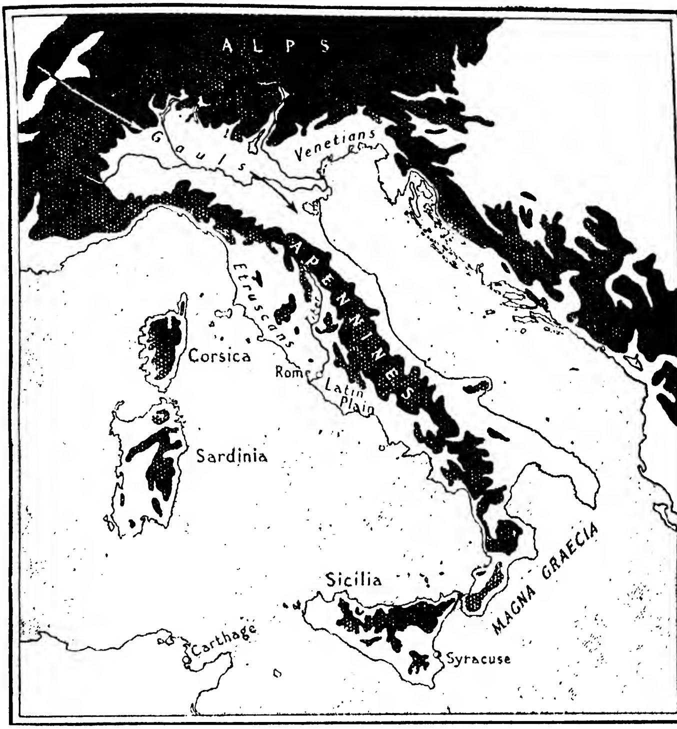


Fig. 9. *Map of the mountainous Italian peninsula showing the commanding position of Rome at the meeting point of traders from the north and south, and the distribution of the various pre-Roman communities inhabiting the area. Note the arrows indicating the infiltration of Aryan-speaking Gauls.*

destroyed by rival traders of the Greek colony of Syracuse in Sicily, just at the time when Italy was being invaded from the north by barbarians from Gaul. The Romans were not slow to take advantage of the opportunity, and no more is heard of the Etruscans!

Continued wars seemed to be the lot of Rome. The Gauls were a persistent menace and in 390 B.C. sacked Rome itself. But they were forced to withdraw and by 300 B.C. Rome was master of the peninsula except in the Grecian south. The Greek colonies had found a protector in a kinsman of Alexander the Great, one Pyrrhus, who on the disruption of Alexander's empire had established himself on the eastern shores of the Adriatic in the little kingdom known as Epirus. Pyrrhus invaded Italy and twice defeated the Romans, but his attempt to incorporate southern Italy and Sicily into his empire

alarmed the Phœnicians of the city of Carthage, just across the waters on the African coast. Carthage sent a fleet to the aid of Rome, and Pyrrhus retreated, to leave Rome and Carthage to fight out the struggle for Mediterranean supremacy—the last great struggle between Aryan and Semitic peoples.

The Roman Empire

The three Phœnician or Punic wars began in 264 B.C. and ended in 146 B.C. They had been fought in Spain, Italy, North Africa, and on the Mediterranean. At the end of them Carthage was burned, its surviving inhabitants were enslaved, its land was ploughed up, its empire taken by Rome. Even between the second and third Punic wars Rome had conquered Macedonia and Syria. With the conquest of Greece and the reduction of Egypt to a tributary province, the Mediterranean had become a Roman lake (see Fig. 10).

While Rome, outwardly so successful, was creating this astonishing empire, there was rottenness at her heart. The extension of Roman citizenship beyond the city itself had reduced the Popular Assembly into a meaningless relic of earlier plebeian victories. The spoils of war and the opportunities for exploitation, the combination of wealth and uncontrolled power in the hands of victorious generals, the growth of large estates in the possession of profiteers who had seized the lands of soldiers burdened with the debts which they had incurred in trying to restore their farms, or in trying to run them in the face of slave-worked farms, were amongst the conditions which were producing widespread wretchedness. During the second and first centuries B.C. such conditions grew steadily worse, while futile revolt merely increased the severity of repression. The maintenance of professional soldiers made authority invincible, and one could not look for pity or mercy in a city born out of commercial opportunity and bred in successful militarism; in a city where slaves were often chained at night, where they could be mutilated or slain at any time, or crucified in batches if one should slay a master; or in a city which found its greatest pleasure in watching hungry lions slay and eat their human victims as a public spectacle in the arena.

Internal Strife

It was inevitable that there should have developed from such a background bitter struggles for supreme authority. First Marius, fresh from African conquest, and Sulla, one of his generals, carried on a struggle in which thousands were massacred. This sordid strife was followed in 73 B.C. by a rising of slaves under Spartacus, a revolt which ended two years later with the lining of the Appian Way with six thousand of their crucified bodies. Crassus, who had defeated Spartacus, aimed at the dictatorship of Rome, but two victorious generals, Pompey the Great and Julius Cæsar, had similar ideas. For a time they shared the power, but Crassus was slain in Persia, and Pompey was murdered in Egypt. Julius Cæsar, conqueror of Gaul, was left in undisputed authority, and in 45 B.C. was made dictator for life.

When Cæsar, influenced perhaps by the flatteries of Egypt's god-queen Cleopatra, began to regard himself as a god-king, and had

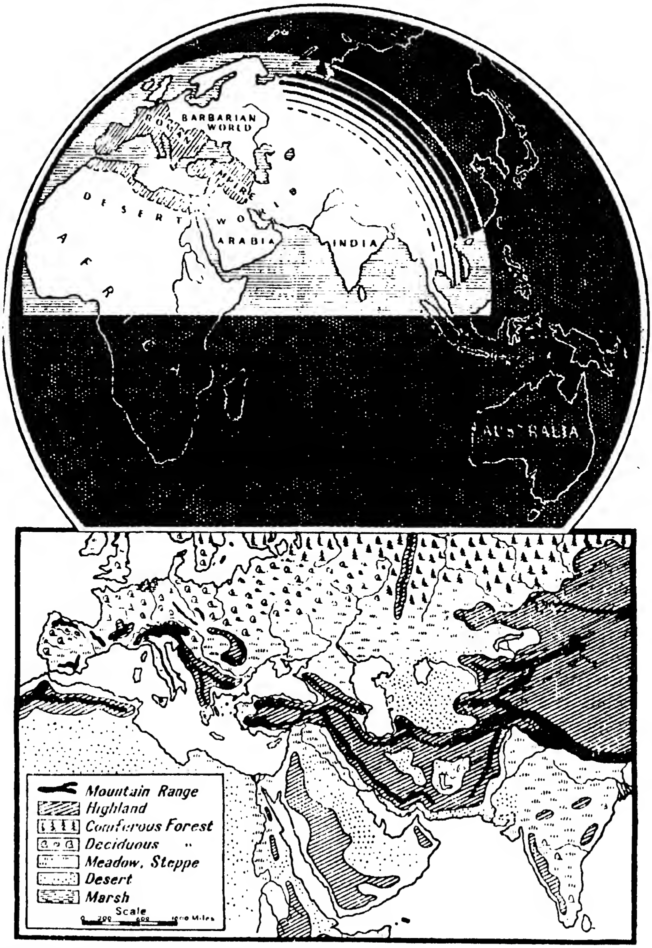


Fig. 10. *The Continental extent of the Roman Empire and the features of the surrounding lands then known to Western peoples. At its greatest extent the Empire also included southern Britain.*

erected in a temple a statue of himself, inscribed "To the Unconquerable God," he aroused the dying flicker of Roman republicanism into a momentary flame. Perhaps some envy was mingled with the republican sentiment, for his murder at the foot of Pompey's statue merely

led to a new struggle for power. The death of Mark Antony left the way open to Cæsar's nephew, Octavian, who, as Augustus Cæsar, became the first of the Roman emperors (27 B.C.-A.D. 14). With the conquest of Britain and Transylvania the Roman Empire reached its greatest extent, from the Atlantic to the Euphrates, from the Rhine and Danube to the Sahara, it embraced the whole of the civilized world of the west.

The Roman emperors, absolutely supreme, regarded as gods after death, and unrestrained, therefore, by any worldly or spiritual authority, with vast wealth, used to habits of cruelty, and often without any intellectual refinement, had unique opportunities and temptations. That many of them led debauched lives of extravagant luxury, vice, and cruelty is not surprising; that there were exceptions who justified their authority is true. Octavian was an exception. In the brief Augustan Age, Virgil, Ovid, and Horace made Latin poetry immortal, while Rome was rebuilt as a city of marble. Other exceptions were Antoninus Pius and Marcus Aurelius. Yet it is this very opportunity for a life of idle dallying at the heart of an empire which endured for five centuries, which proves the efficiency of the machinery which controlled it and which kept it at peace.

Civilizing the Provinces

It was in the interest of Rome that her provinces should be developed. Marshes were drained, forests cut, mineral wealth was explored, methods of cultivation were improved and cultivated areas were extended, new commodities were introduced, law and justice were enforced, and trade was developed. Backward lands like Britain and Gaul, lands which were the most remote of Rome's provinces from the Mediterranean centres of civilization, were urbanized and, throughout Gaul and in south-east Britain at least, an orderly and civilized life replaced a relatively primitive and priest-ridden existence.

In addition to these material advantages Rome gave to her provinces a new sense of unity. This new self-consciousness, almost an incipient nationalism, was particularly noticeable in Britain, which was changed, during the four centuries of Roman occupation of the greater part of it, from a group of rural, tribal communities into a political entity. Rome, after all, was but a city, whereas her empire comprised the whole of the Western civilized world. It was necessary, therefore, that she should have taught the peoples of her provinces to rule and organize and develop themselves under the direction and control of Roman administrators or administrators who had become sufficiently Romanized. Rome had begun the experiment of world statecraft, an experiment which has not yet been completed.

It is superficially a paradox that, while Roman occupation tended to develop some feeling of nationalism in the Roman provinces, the Roman Empire remained essentially a unity in itself. Yet the one implies the other. The civilization was Roman; the cities which grew in places as remote as York, or Chester, were miniature Romes, with a forum, centrally heated villas, and Latin-speaking inhabitants; roads, at first used for military purposes, soon became com-

mercial highways and the connecting links between the towns and Rome itself. Moreover, the developed trade was an imperial trade. Britain, Egypt, and North Africa exported corn; Britain, too, supplied skins, lead, oysters, tin, and perhaps wool; textiles, often richly embroidered, even paper and glass, came from Egypt, while Eastern lands sent spices, precious stones, and, as yet a rare luxury, silk.

A greater paradox is one which G. K. Chesterton, that lover of paradoxes, has pointed out: "Rome itself, which had made all that strong world, was the weakest thing in it." Rome contributed neither goods nor economic service for the wealth she imported. Metal, wrung from provinces as tribute, was converted into money in the imperial mints, and used as payment. Indeed, few of the increasingly wealthy minority contributed directly to the empire's wealth. Money-lenders paid with the forfeited securites of unfortunate debtors or with exacted interest; generals paid with money obtained from the sale of spoil or the rewards of conquest; governors, having the right to tax, sold it to professional tax-gatherers. The basis of Roman life from its origin was a fusion of commercialism and militarism. Consequently, Roman civilization was essentially practical, but of a worldly and materialistic quality. The great impetus which Greek civilization had given to imaginative thinking and to creative art degenerated into an acceptance of knowledge and mere imitative craftsmanship. Wealth and power replaced knowledge, truth, goodness and beauty, as criteria of value. Yet it was in a Roman province, in the reign of the first of the emperors, that the revolutionary teaching of Jesus Christ was condemning selfishness, hypocrisy, ignorance, worldliness, and like human weaknesses, to very unwilling listeners.

Growth of Christianity

Whatever theological or other interpretations may be put on Christ's teaching, and quite apart from the acceptance by the Christian world of Christ's own divinity, his teaching presented an ideal of human behaviour which has done more to revolutionize Man's conception of himself and of his human relations than any other event in human history. A doctrine of the universal brotherhood of Man, a doctrine which preached love, friendliness, and forgiveness as the highest motives of human conduct, and which condemned selfishness and greed, a doctrine disturbing enough now, was revolutionary then. It angered the Jews by denying their claim to be the "chosen people"; it angered the priests, whose hypocrisy it condemned; it angered the wealthy in its denunciation of the co-existence of individual wealth and individual poverty. The cry of Jesus, as they crucified Him: "Father, forgive them," epitomizes His life and teaching.

The very activity of Christ's surviving disciples forced Rome to abandon its general policy of religious toleration or indifference, and to persecute the Christians. But Christianity was indestructible; its teachers spread throughout the empire and beyond its frontiers into the barbarian world beyond the Danube. Three centuries after the birth of Christ, persecution reached its climax. The Emperor Diocletian ordered the destruction

of all Christian churches, the execution of all Christians, and the confiscation of all Christian manuscripts and general property throughout the empire.

The Eastern Empire

While Christianity was growing, Rome's imperial power was weakening. The eastern half of the empire, which had always remained essentially Greek, broke away from the Latinized west in Diocletian's reign. The city of Byzantium, an almost impregnable fortress, controlling the entrance to the Black Sea and, therefore, many of the ancient trade routes, was replacing Rome as the main city of the breaking empire. In A.D. 328 Constantine, who had succeeded Diocletian as emperor after a period of anarchy, made his capital at Byzantium, which, though renamed New Rome, became known as Constantinople. In A.D. 337 Constantine the Great, the son of Helena, a woman of Britain, made a further revolutionary change by being baptized as a Christian, ordering the cessation of all persecution, and adopting Christianity as the religion of the empire.

While the organization of the Christian Church was gradually creating a new unifying force in Western Christendom, the empire was equally rapidly disintegrating. Weakened from within by the corruption, greed, and rivalries of its officials, it was increasingly threatened by attack from the barbarian peoples who, across the Danube and Rhine, had remained a world apart beyond the frontiers of Rome's civilization. Pressed from the north-east by Mongolian tribes from Asia, and tempted by the weakening resistance of the Roman armies at the frontiers, Goths and Vandals in the fourth century were crossing the Danube and invading Italy and the Balkans; Franks were pouring across the Rhine into Gaul; English from the mouth of the Elbe were rapidly turning the lowlands of Britain into England.

Though the purple of empire had passed from Rome to Constantinople, round which a fragment of the empire survived as a dwindling remnant for a thousand years, Rome was to be invested with a new and equally enduring authority. In the confusion which, in Western Europe, followed the barbarian settlement of the empire, the Church survived as the one organized and civilizing institution. The recognition of the Pope as its head, and the development of monasteries in which men sought shelter from the chaos of the barbarian world, combined to create another kind of Roman Empire, "a Christian Empire ruled by the Pope, whose outposts were the walled abbeys scattered in increasing numbers in a confused world of warring barbarians."

Evolution of Feudal Christendom

A glance at Europe in the eighth century (see Fig. 11), after three centuries of chaos, destruction and settlement on the ruins of the Roman Empire, reveals in outline the pattern of a number of definite developments. First, the characteristic social structure of the new settlements was that known as feudal, a society essentially rural, and consisting of peasants who work the land which a fighting aristocracy holds from a chieftain who owns it. Such a society was an inevitable development when rural

Fig. 11. *Europe in the eighth century. Feudal states were well established in the west and centre, but nomadic peoples still advanced in the east. The Moslems had, by this time, made extensive conquests.*

communities took to conquest. The temptation of a successful chieftain to extend his land, and therefore his authority and wealth, produced the little feudal states, duchies, counties, and the like, which in time grew into the national monarchies out of which modern Europe has developed.

The second observation would be that the feudal and monarchic development was strongest where the tradition of a civilized urban life was weakest. A fragment of the Roman Empire, with its capital at Constantinople, survived in the Balkans, Asia Minor, northern Egypt, and some Mediterranean islands; in Italy the Papacy and a considerable urban life survived; in Spain and France feudal kingdoms had been established, but the Latin tongue, and a considerable degree of culture and respect for Rome, continued; in Britain the lowlands had become England, and the highlands a Celtic stronghold. Eastern Europe, which had never known an urbanized life, which lay in the track of Asiatic invasion, and which was poorer in climate and resources than the west and south, remained backward and confused.

In the third place, the Church, under the rule of the Pope, had enormously increased its power and influence. The struggle of the Papacy to save Italy from barbarian conquest had at once strengthened and secularized the Papal office. A series of great Popes, Innocent I, Leo I, Gelasius II, and Gregory the Great (A.D. 590-604), had elaborated ritual, strengthened their control over the monasteries, sent out

missionaries—it was Gregory who sent St. Augustine to convert the English—and administered their growing estates in Italy after the manner of ruling princes.

Charlemagne's Empire

The greatest of the feudal kingdoms was that of the Franks, or France. Under Charlemagne (A.D. 768-814) it included also Frisia (the modern Netherlands), German and Slavonic territory to the north-west corner of the Balkans, and part of Italy. The conquest of the Lombard invaders of northern Italy, and the assumption of their iron crown, had been undertaken at the request of Pope Leo III, who rewarded Charlemagne by crowning him as Roman Emperor on Christmas Day, A.D. 800 (see Fig. 12).

Thus the old imperial dream lingered. But Charles had received the crown, now the symbol of a vanished power, from the hands of a Pope. Its new significance was that it symbolized the convenient union of two forces, the traditional authority of Rome expressed through the power of the Papacy, and the growing power of feudal monarchy, already strong enough to be sought as Rome's protector, later to supplant it. It is this partnership of the medieval Church with medieval monarchy which is fundamental to the conception of feudal Christendom. Yet, in an important sense, the two forces are basically opposed. That of Rome implied the continued unity of Europe, a conception which implied the continued unity of the Church, absolute and disciplined obedience, and the vigorous suppression of heresy. On the other hand, feudal monarchy was hammering sections of Europe into independent national states; it was developing national independence and, in turn, that independence of thought which broke loose from

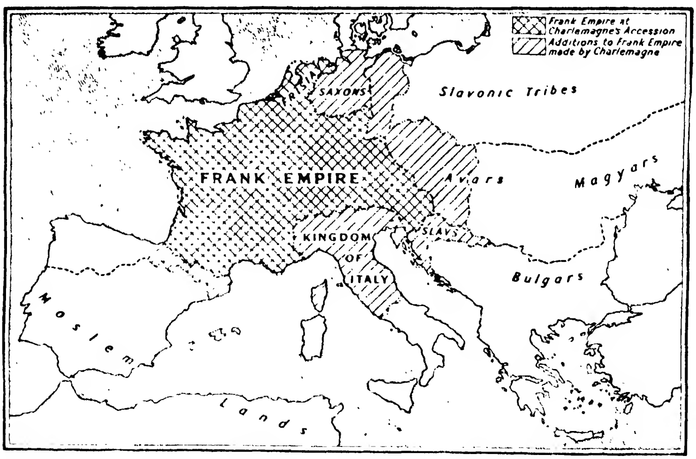


Fig. 12. *The Empire of the Franks, showing the Saxon, Slav and Italian territories added during the reign of Charlemagne.*

imposed authority, whether of rule or of creed.

At first, however, monarchy accepted the union and gained from its acceptance. Monarchy gained in dignity and in idealism; it began to encourage the redevelopment of art and learning, to share with bishops the work of ruling and of justice, and to encourage the building of churches and monasteries. The Church softened the brutality of the barons by the institution of chivalry, restrained oppression and, though it grew worldly and wealthy enough in the process, kept alive the concept of human spirituality.

In A.D. 843 Charlemagne's empire was split into three sections by his grandsons: the kingdom of France, a loose unity of feudal duchies called Germany, and a central kingdom including Lotharingia and Burgundy (see Fig. 13). This division led to boundary disputes which have not yet ended. In A.D. 962 the imperial crown was given by Pope John XII to the most powerful of the German dukes, Otto of Saxony, and Germany, for nearly nine centuries, was known as the Holy Roman Empire.

Irruption of the Northmen

From north and east Europe, new barbarian irruptions had begun to disturb the developing feudal Christendom. The adventurous Vikings, or Sons of the Fjords, from the harsh lands of Scandinavia, plundering villages and monasteries, and penetrating far up rivers in their narrow ships, were establishing settlements in many lands (see Fig. 14). In England Alfred and his successors saved for a time the Wessex kingdom from them, but a century later England was united under the Danish king, Canute who was King of England from 1016-1035. Already, in A.D. 911, the Viking settlement of northern France was recognized as the Duchy of Normandy. Rurik and his Northmen had begun the history of Russia as an organized state, other Northmen had settled in Sicily, while still more adventurous explorers had reached Iceland, Greenland, and North America. A characteristic of these Northmen was their tendency to adopt the habits, language, and customs of the peoples of the lands they had entered, and the Norman conquest of England in 1066 was essentially a conquest by men who had become thoroughly French, who had acquired much of France's superior culture, and who in time were, after their fashion, to become absorbed in the English nation which they had helped to hammer into self-conscious unity.

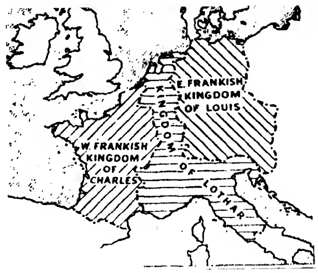


Fig. 13. *Triple partition of the Frank Empire in A.D. 843.*

Weakening Feudal Structure

By the eleventh and twelfth centuries changes were already occurring in each of the four characteristic elements of the medieval European society, national monarchy, the feudal baronage,

the peasantry, and the Church. Two important changes in monarchy were its increasing independence and growing sense of responsibility. Royal attempts to restrict Papal interference were made in England and France, while a struggle developed between the Emperors and the Popes for a supremacy which, in practice, neither possessed. Kings, again in France and England especially, were developing systems of law and justice which embraced all classes of their subjects. The great landholders, whether barons, bishops or abbots, were already developing into a settled aristocracy, with a measure of control over monarchy, a growing interest in wealth, and, in the case of the barons, a growing tendency to exchange traditional feudal obligations for a money payment. The peasants had been depressed into a condition which, with few exceptions, was not far removed from serfdom and which frequently was serfdom. The Church was by this time becoming increasingly secular, wealthy and rigid.

But no rigid system of authoritative knowledge, of imposed beliefs, or of monastic self-repressive idealism, could smother for long the freedom and independence of thought or stifle the imagination of a people who had both ingrained in them. Troubadours, minnesingers, minstrels and others were singing and reciting romantic poetry in France, Germany, and England. Great cathedrals and monasteries were expressing in stone Man's undying love of the beautiful. Groups of scholars continued the unending search for truth and knowledge, and began to settle in convenient places for discussion and the centralization of manuscripts. Thus began the universities: at Salerno, famous for its school of medicine; at Bologna, where the study of law was revived; at Paris, the resort of philosophers and theologians, from whence English scholars were summoned to open a similar seat of learning at Oxford

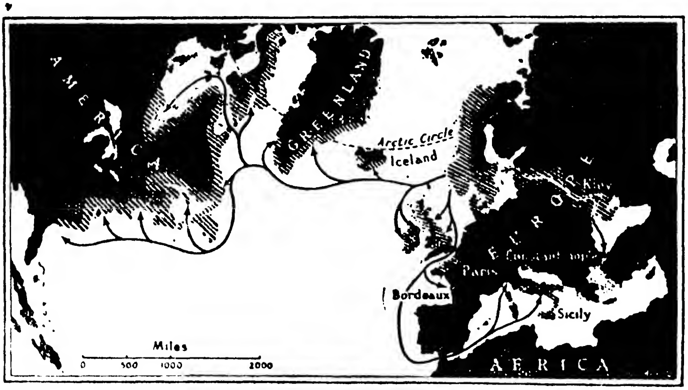


Fig. 14. *The astonishing voyages of the Vikings. Their longboats reached the shores of Iceland, Greenland and North America, while they made settlements in France, Russia, Britain, Italy, and Sicily.*

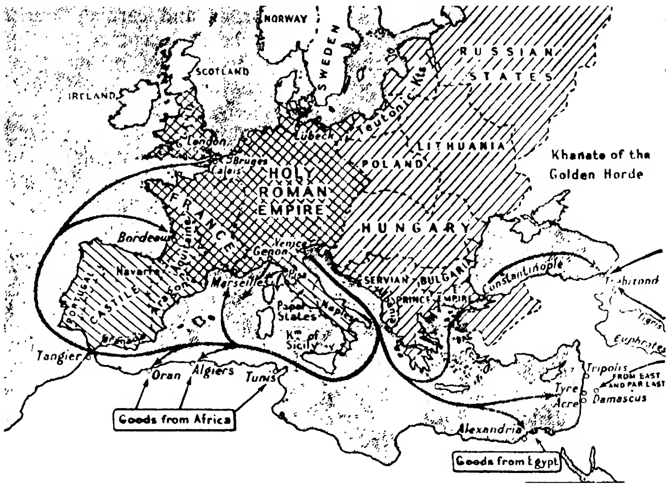


Fig. 15. *Commercial development of medieval Europe. Note the predominant position of Venice and the towns of northern Italy as distributing centres for luxury goods imported from the East.*

in 1167. Already in the twelfth century were signs of the coming revolt against the wealth and doctrinal authority of the Church, and healthy heresies like those of the Albigenses, or of the Poor Men of Lyons, or of the Waldenses, were bringing men to the stake.

European Commerce

While the authority of the medieval Church was thus being already threatened, the feudal structure of society was being threatened equally by urbanization and the growth of commerce. Feudalism is essentially a rural organism, a society of landowners and peasant workers. Consequently it had never taken such deep root in the Mediterranean lands, where city life had existed longer, as it had in the more recently Romanized Gaul and Britain, or in Germany and the Eastern lands which had never been part of the Roman Empire. Thus, a city and commercial life had continued in Italy, in the Balkans, and in Spain, and had spread thence first into Germany and France, and later into England (see Fig. 15). The Norman Conquest brought England into touch with an already extensive system of European trade, centred round the wealthy Mediterranean ports of Genoa, Pisa, Venice, Marseilles, and Constantinople. Fairs for the exchange of goods were organized, mainly under the direction of bishops, at the river towns which were growing round the cathedrals. Merchants, who had no place in any feudal conception of society, were growing in number, wealth, and power, while towns which they, in the main, controlled were buying independence from feudal control. Only

in the east did life remain almost wholly rural, with a miserably wretched peasantry crushed and almost dehumanized by an ignorant feudal aristocracy.

Early Chinese and Indian Civilizations

Thus far the story of human development has been confined within the relatively narrow limits of Europe and south-west Asia, or, more particularly, of the lands round about the Mediterranean. The Church's call to European chivalry to protect the Holy Sepulchre and the Holy Land from Asiatic invaders who had begun to oppose Christian pilgrims and traders, a call which was answered by the Crusades, began to turn the eyes of Europeans towards lands and peoples beyond the frontiers of their narrow world. It is our first opportunity to glance at the mysterious land of Asia.

Asia in general is much less hospitable to Man than is Europe. Far removed from the influence of the warm winds and ocean currents which temper the climate of western Europe, and exposed to the ice-cold winds from the Arctic, the Great Siberian Plain is a land of ice wastes, coniferous forest, steppe, and desert. It is clear, therefore, why Asiatic peoples should have sought as a home the fertile valleys of the Tigris and Euphrates, the Ganges, and the Yangtze, and why Asiatic civilizations should have been concentrated in these regions.

Chinese civilization is probably as old as that of Egypt. At least two thousand years B.C. there were cities, temples and writing in China. After a period of prosperous development under the Shang Dynasty (1,750-1,125 B.C.) China fell into an Age of Confusion in which, however, art and learning flourished. In the sixth century B.C. Confucius, like many of his Greek contemporaries, was developing a philosophy, advocating a disciplined and unselfish life, and searching for a ruler to establish the ideal state he envisaged. By the third century B.C. China had entered on a new era of reconstruction, especially under the rule of Shi-Hwang-Ti, who began the building of the Great Wall against the barbarians who lived beyond the frontiers of this as of all the ancient civilizations.

Essentially similar is the ancient history of India, into which, some two or three thousand years B.C., Aryan-speaking peoples had penetrated. After a long struggle with the aboriginal Dravidians, most of whom were driven south, the invaders began to develop a civilization in the northern plain. By the sixth century B.C. there were organized states and cities, centres of wealth and luxury round which were scattered the wretched villages of the poor; there were wealthy nobles, powerful priests, and the inevitable substrata of workers, peasants, the old and the crippled, and the like. These social layers had hardened into rigid hereditary castes. In these early days there were four such castes: the noble Kshatriyas, the Brahmins or high priests, the Vaisyas or peasants, and the Sudras, the "hewers of wood and drawers of water," who were probably descended from the conquered Dravidians.

Confucius and Buddha

In the sixth century B.C., when Confucius was founding his philosophy in China, Gautama Buddha was preaching in India the doctrine

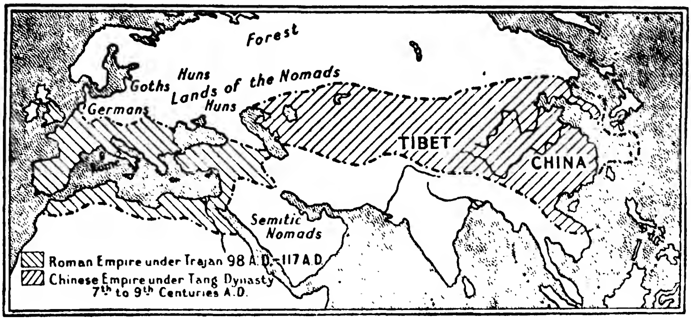


Fig. 16. *Map showing the territories of the Roman and Chinese Empires at their greatest extent, which stretched respectively from the Atlantic and the Pacific Oceans to the Caspian Sea.*

that happiness could only be achieved by the living of an unselfish life. But whereas Confucius's teaching remained a practical and idealistic mode of life, Buddhism developed into a religion in which the initial doctrine was so encrusted with ritualism and mysticism that Buddha himself would have failed to recognize it. In India, as in China, it was in the third century B.C. that a great ruler, King Asoka, was inaugurating an era of reconstruction, distinguished by an unusual benevolence. Education was developed, hospitals were built, wells sunk, and Buddhist missionaries sent out to Burma, Siam, and even to China where Buddhism took firm root. In India Brahminism was too powerful to be altogether replaced, and modern Hinduism is derived from both sources.

The Chinese Empire

After the death of Shi-Hwang-Ti China began to spread westwards, over Tibet, the Pamirs, and Turkestan, reaching at its greatest extent the Caspian in the west and Annam in the south. Thus there developed two great empires, the Chinese and the Roman, extending respectively from the Pacific and the Atlantic to the Caspian, and, between them, they comprehended most of the civilized world (see Fig. 16). To the north of each lived barbarian tribes—the Nordic English, Franks, Goths and Vandals of Europe, and the Huns, Tartars, Turks, and similar Mongolian peoples of Asia. Chinese expansion had set into motion many Asiatic tribes, and for several centuries there was a steady drift of Mongolian peoples into Europe, where they made settlements in Finland, Esthonia, Russia, Bulgaria, and Hungary; others were spreading into Persia, and these, known generally as Turks, gradually dominated Asia from China to the Caspian. Others crossed into India through the Khyber Pass. In the East as in the West, therefore, the first millenium of the Christian epoch saw the gradual infiltration of barbarian peoples into an imperial civilization, and the establishment of their settlements on its ruins. Both groups of settlements were to receive a shock, from the deserts.

It was from the deserts of Africa

and Arabia that shepherd nomads had, in the past, left their leisurely nomadic life to create the great civilizations of Egypt and Mesopotamia; they had built Jerusalem, laid the foundation of Mediterranean trade, and given Christianity to the world. In Arabia, where regular caravan routes had long developed, merchants had settled on oases where water supply was adequate, and two such settlements had grown into the cities of Mecca and Medina. Mecca, the larger city, was also a shrine, and had grown wealthy as the annual resort of vast numbers of pilgrims. Jewish and Christian traders came to Mecca, too, and it was possibly from them that Mohammed, a native of the city, first learned of the conception of an Unseen God.

The Moslem Empire

When Mohammed began to preach the doctrine and to make converts, the Meccan people, alarmed at the possible loss of the wealth they derived from the pilgrims, drove him out. His flight to Medina in A.D. 622 is known as the Hegira (pronounced Heej-ra), and is the event from which the Mohammedan Calendar is dated. Seven years later Mohammed returned as master of Mecca, and began the conquest of Arabia, as the Prophet of Allah, the Unseen God. At his death in A.D. 632 Mohammed was succeeded as Caliph by Abu Bekr, who planned the conquest and conversion of the world. A century of amazing conquests followed. By A.D. 750 the Moslem Empire had spread eastwards from Arabia, Syria and Armenia through Persia to Turkestan; it had spread westwards through Egypt and northern Africa into Spain where the Franks, under Charles Martel, the grandfather of Charlemagne, halted the Moslem progress.

Within the Arabic Empire developed an astonishing culture. The Moslems gave to the world the mathematical sciences of algebra and trigonometry, an efficient numeral system still known as Arabic, the foundations of astronomy, and of chemistry. They learned from the Chinese, who were conserving their civilization if not their empire, methods of paper-making and printing. By the ninth century the Arabic Empire, especially in Egypt and Mesopotamia, was far more civilized than Europe, with an intellectual life which kept alive the knowledge of Greek learning and philosophy.

By the eleventh century the steady drift of Turkish tribes had begun to threaten both the Arabic Empire and the Byzantine remnant of the old Roman Empire. These Turks, known as Seljuk Turks, who had adopted Islam, were less intellectual and far more fanatical than the Arabs, and when their advance through Mesopotamia, Armenia and Syria brought them to the threshold of Constantinople itself, the Emperor appealed to the Pope to call on the chivalry of Europe to save Christendom and the Holy Land from the infidel (see Fig. 17).

The Crusades

The Crusades, the Holy Wars of the Cross, though they failed permanently to regain Jerusalem or to stem the advance of the Turks, and though they were fought with decreasing enthusiasm and disinterest, influenced European life in many ways. Christian zeal combined with commercial jealousy led, in England as elsewhere, to massacres of Jews;

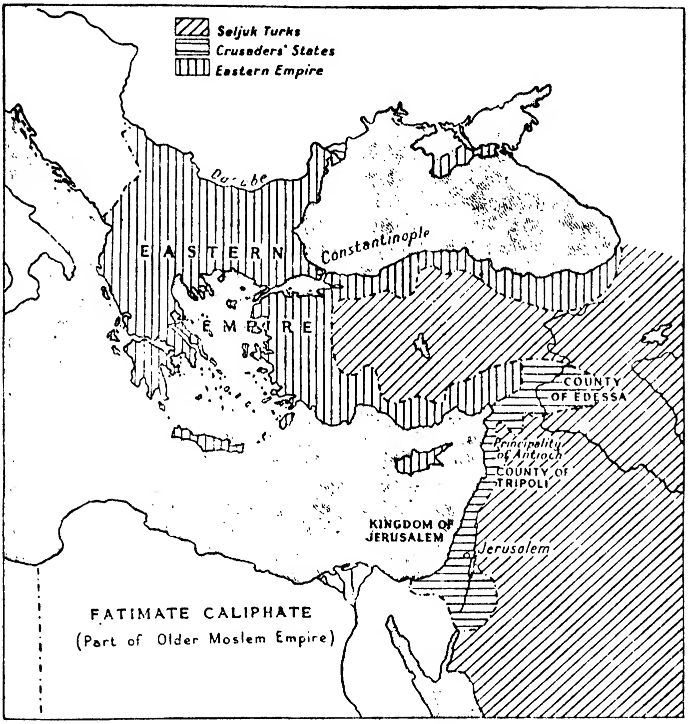


Fig. 17. *The eastern Mediterranean at the time of the early Crusades, showing the territories held by the original Moslem Empire, the Moslem Turks, the Crusaders, and a remnant of the Roman Empire.*

barons from the West made personal contact with the superior culture and greater luxury of Mediterranean life, as Europe in general learned of the superior knowledge of the Moslem world. New goods for commerce and for production were introduced into Europe; trade increased in scope and extent; new privileges were claimed by Venice from crusaders in return for the loan of her fleet, and it was on behalf of Venice that the fourth crusade was diverted to the conquest of Constantinople. Merchants began to make longer and more adventurous journeys, and soon discovered the wealth of China.

The Golden Horde

In the twelfth century the Mongols of central Asia were welded into a great fighting force by the fierce Jenghis Khan, a name which means "Great Ruler." Before his death in 1226 he had conquered north China, north India, Turkestan, Armenia, and Persia. His son

continued this amazing success by conquering the greater part of Russia and Poland. In 1241 he invaded Germany, and his terrifying army, known as The Golden Horde, seemed about to conquer Europe. On the death of Ogdar Khan, however, this unwieldy empire was divided amongst his sons, of whom one, Kublai Khan, founded a new dynasty in China. Whereas the Chinese people were generally conservative, with a tendency to be exclusively interested in themselves, Kublai Khan was anxious for knowledge of the outside world. Accordingly, when two adventurous merchants from distant Europe, the Venetian jewel-merchants Nicolo and Maffeo Polo, were brought into his presence, they were welcomed by the intelligent Khan. Later he sent them back to Europe with the request that they should return with a hundred teachers to instruct his people in the ways of European life. They returned in 1272 with their nephew, Marco Polo.

Marco Polo stayed in China for twenty years. The wealth he brought back, and the story of his travels which he later dictated, added a new stimulus to Europe's already extensive Asiatic trade. Clearly, Europe was rapidly ceasing to be a purely feudal community, or indeed a community restricted to a European field of activity.

Transition from the Middle Ages

By the thirteenth and fourteenth centuries the essential characteristics of medieval European life were rapidly disappearing, particularly in the west. Firstly, a series of changes were undermining the long established authority of the Church, and the correlated conception of a united, Latin-speaking Europe under Papal domination. The Church and the Papacy had lost much of their prestige and power through their long struggle with the Empire, and through the generally increased secularization of the Church. An attempt by Pope Boniface VIII to enforce the old Papal claims was successfully challenged by Edward I of England and Philip IV of France. In 1309 a French Pope was appointed, and until 1377 the Popes lived at Avignon as puppets of the French monarchy. This humiliating Babylonish Captivity represented more than a monarchic and national victory over the Papacy; it was possible only because the Church had lost its greatest source of strength, the support of the people.

Grey Friars (the followers of St. Francis of Assisi), Lollards (the disciples of Wycliffe), and many others, had already gone out amongst the poor and the suffering, to carry out their conception of a practical Christianity. Chaucer, in the fourteenth century, was satirizing the monk grown greedy and praising the unselfish labours of the parish priest. Others, such as Marsiglio of Padua, or the French Gerson, known as The Most Christian Doctor, were challenging the authority and doctrines of the Church and advocating democratic doctrines and the secularization of Church lands. In 1378, at the end of the Babylonish Captivity, there were two rival Popes for nearly a century, one elected by French cardinals, the other by Italian.

Furthermore, just as there was a growing and increasingly widespread revolt against the unity, authority, worldliness, and rigid teaching of the Church, so there

were forces which were rapidly altering the structure of medieval European society. The most important of these was the growth of towns, for an urban and a feudal society are mutually contradictory terms. Towns demand many specialists, as we have previously observed, and specialization implies the exchange of goods. The early trade between town and outlying district, the exchange of manufactured goods for food and materials, had grown into a much wider commercial system, which finally reached out as far as India and China. Merchants, who had no place in a feudal structure, had long protected themselves in Italy, France, Germany and, by the twelfth century, in England, by forming guilds, which, protected and privileged, began by controlling all trade and ended by controlling the towns themselves. Craft guilds followed for the protection of craftsmen and of the mysteries of special crafts.

Most of the luxuries imported into Europe, such as spices, precious stones, silk, fine tapestries and textiles, ivory, scented wood and the like, were brought and distributed by merchants of the north Italian towns, of which Venice was the most important (see Fig. 15). Most of the goods produced in Europe, particularly northern and central Europe, were distributed by the merchants of the great league of towns known as the Hansa. England was relatively late seriously to enter the commercial field, but wool began to play a part in English politics soon after the Norman Conquest.

Just as merchants and craftsmen were becoming independent of feudal control, so barons were gaining freedom from the Crown by the substitution of money payments for service. By a process superficially similar to this commutation of feudal service, the peasants of France, Germany, and England had begun to work for wages. They had, however, substituted for a life hitherto protected a life dependent on their capacity to sell their labour. In 1348, after a long period of wars against France, the English nation fell a victim to a plague known as the Black Death, which destroyed from a third to a half of the English population. The consequent scarcity of labour gave the peasants the opportunity to demand higher wages, and when a series of Statutes of Labourers imposed heavy penalties on any who received or gave such increased wages, the peasants rebelled. Similar revolts occurred in France and Germany. A second result of these changes in the conditions of peasant labour was that landowners either faced increasing impoverishment by having to leave their lands unworked or but partly worked, or were compelled to turn their arable fields into pasture in order to make money by selling wool to the merchants. The subsequent complete transference of authority from the landowner to the merchant, from a feudal to a commercial society, was foreshadowed.

The Renaissance

The various groups of revolutionary changes gradually merged into a single but complex movement, at once national, democratic and intellectual, towards freedom and self-expression. The Renaissance of the fifteenth century is the climax of this long process of national, social, spiritual, æsthetic, and

intellectual emancipation from authoritative repression. The Renaissance, therefore, comprehends not only a new creative urge in the arts or a new enthusiasm for learning, but also the Reformation of the Church and the geographical discoveries which moved the European centre of importance from Italy to the Western nations.

The denunciation of Papal claims and of orthodox doctrine by the German Luther merely focused the general and complex factors which had long been undermining the unity of the Church. Nationalism was expressed in the formation of national Protestant Churches as in Sweden, Denmark, England, Poland, and Hungary. It was expressed also in the translating of the Bible and in the use of the vernacular tongue for public worship. The challenge to constitutional authority was expressed in the democratic Churches which followed Calvin, and in the attempt within the surviving Roman Catholic Church to substitute the authority of a council for that of the Pope. Intellectual freedom was expressed in the frank and scholarly discussion of doctrine. When the people were articulate at all they demanded the same kind of sympathy which Christ had extended to the poor. Unfortunately, the new Churches were as intolerant of other points of view and as tolerant of the co-existence of wealth and poverty as the medieval Church.

The new spirit of inquiry was helped by the European discovery of the ancient crafts of printing and paper-making. The availability of printed books began to lay the ghost of ignorance. The study and group discussion of the writings of the Greeks opened a new world of knowledge and speculative reasoning to students, and an attitude to life, a humanist and self-expressive attitude, with which the new age in Europe found itself in enthusiastic sympathy. There were revolutionary pioneers in every field. Bacon, Galileo, and Copernicus had re-lit the torch of scientific inquiry; in Italy, Leonardo da Vinci, Michelangelo, Raphael, Correggio and others were revolutionizing the arts of painting and sculpture; music in England reached, in the polyphonic madrigals and the music for viols, unprecedented perfection, as did poetry in the works of Wyatt, Surrey, Jonson, Marlowe, Sidney, and the incomparable Shakespeare.

Expanding Trade Routes

The Greeks had suggested that the world was spherical, and Eratosthenes of Alexandria had stated with reasonable accuracy the length of its circumference. The French scholar, Pierre d'Ailly, reaffirmed its spherical nature and suggested that eastern Asia could be reached by ships sailing westwards over the unexplored Atlantic. New trade routes to the east had become imperative through the continued advance of the Turks, who, in 1453, captured Constantinople and began to threaten eastern Europe. Already the Portuguese, urged by Prince Henry the Navigator, had begun to search for a sea route to the east round the unknown Africa, and, in 1498, Vasco da Gama succeeded in reaching India. Much of the African coast was explored, Portuguese trading depots were opened in the Far East, and Albuquerque hammered out a Portuguese Empire on the shores of the Indian Ocean. In 1492 Columbus, financed by King Ferdinand and Queen Isabella,

whose marriage had created a united Spain, reached what he believed to be the Indies. Though he never knew it he had stumbled on the threshold of a New World. Another blow had been struck at the power of Rome, for the centre of European importance was rapidly to pass from Italy and the Mediterranean to the Western nations and the Atlantic. France, the new and vigorous little nation of Holland, and rapidly awakening England were soon to challenge the monopolistic claims of Portugal in the east and those of Spain in the newly discovered and almost empty continent of America (see Figs. 18A and 18B). With the development of commercial and imperial rivalry between the nations of western Europe the modern age had begun.

Evolution of Modern Europe

It is possible to indicate only in the barest outline the changes which the rapid development of national self-consciousness has brought about in the political structure of modern Europe. From the sixteenth century to the end of the eighteenth, Europe is best considered as being in three stages of development. In the west were the strong nation-states of Spain, Portugal, France, Holland, and England, to which last in 1707 and 1801 Scotland and Ireland were respectively united. In the centre were the many states, small and great, which formed the Holy Roman Empire and Italy; with Sweden's dominions, which included Denmark, Norway, and the greater part of the eastern littoral of the Baltic, lying to the north. In the east lay the racially divided and politically confused Hungary, the anarchic and disintegrating Poland, the Turkish Ottoman Empire with its depressed and Christian subjects, and the Asiatic and feudal Russia spreading vaguely through its forests and steppes into Siberia.

Social Trends in England and France

The Tudor rule of England (1485-1603) had created a new commercial aristocracy, strengthened Parliament, established the Protestant National Church, and turned a half-conscious nationalism into an enthusiastic patriotism, especially after the defeat of Philip II's Spanish Armada. But before England could be safely launched on her commercial and imperial course, under the control of a capitalist régime, the newly empowered merchant class had to defeat the last representatives of the old order, which the aristocratic Stuarts attempted to revive. The defeat of the Cavaliers in the Civil War is essentially a defeat of a landed aristocracy and a feudal conception of monarchy, supported by a very medievally minded Church, and a victory for the merchants who, by the eighteenth century, controlled the government of the country. That it was also a victory, after 1689, for parliamentary rule was a necessary consequence. The control of the nation's expenditure and revenues passed into Parliament's hands, and in 1694 the Bank of England was founded and the National Debt floated.

France, after a period of civil war, was restored to order by the first of the Bourbon French kings, Henry IV, a progressive materialist like the English Tudors. He encouraged the development of France's resources, introduced new industries, and sent out settlers and explorers into North America. But

Fig. 18A. *The medieval European conception of the world, with western Europe at one edge and eastern Asia at the opposite, is shown by this map based on one drawn by Fra Mauro in the fifteenth century.*

whereas in England this kind of development was encouraged for a century before the Stuart kings tried unsuccessfully to re-establish a more feudal conception of rule, in France the reactionary sovereigns who followed Henry IV succeeded for 175 years in maintaining absolute monarchy and a privileged aristocracy while both were, in fact, a stifling anachronism. While England, therefore, was advancing in material prosperity and a rather gross worldliness, France had the compensation of considerable æsthetic development, in a land which, under Louis XIV and Louis XV, rushed headlong towards national bankruptcy.

Anglo-French Trade Rivalry

With Spain and Portugal sinking into a relatively harmless inactivity, and Holland defeated, the way to world supremacy in commerce lay open to France or to England. Trading companies of the two nations vied with each other in India, while French and British settlers in North America came into inevitable conflict. A series of wars in the eighteenth century left the

Fig. 18B. *The discovery of the New World by Columbus overturned the medieval conception and put Britain and western Europe at the focal point of the world's expanding trade routes.*

United Kingdom mistress of the seas, an unrivalled commercial power, and with a growing oversea empire.

France, increasingly aware of the stifling influence of the surviving power and privileges of a merely decorative aristocracy and court, at last overthrew the obsolete régime in the bloody revolution which began in 1789. Essentially the French Revolution was a repetition of the English Civil War, except that its long postponement made it all the more terrible, and all the more dangerous to other states where despotic monarchy and feudal aristocracy still survived. The war which revolutionary France had to wage created the opportunity for Napoleon, the most successful and unscrupulously ambitious of the generals, to establish a military dictatorship.

Disunity in Europe

The defeat of Napoleonic France, after more than twenty years of fighting, left Britain at the beginning of the nineteenth century free to complete her development as the first industrial specialist on a

national scale, while Europe was to continue, for the greater part of the century, the struggle to overthrow surviving aristocratic and despotic rule.

Meanwhile in Italy the absence of any strong central authority, ecclesiastical or civil, and the jealous rivalries of the little principalities which had grown round the rich city states, left Italy a prey to her more powerful neighbours, and she sank into an impotence from which she did not emerge until the nineteenth century. Similarly, in Germany, or rather the Holy Roman Empire, the independence of powerful princes, lay and ecclesiastical, and the fictitious nature of imperial authority, had prevented the development of national unity. The war which began in 1618 as a religious struggle between the Roman Catholics and Protestants of Germany, and which, through the intervention of France, Spain, and Sweden, lasted for thirty years in the Empire, left Germany impoverished and hopelessly divided. The fiction of empire lasted until 1806, when Napoleon abolished it and transferred the imperial crown to his own head.

Of the many states which had gone to form the Empire, two, the Archduchy of Austria and the Electorate of Brandenburg, had outgrown the others. The Hapsburg rulers of Austria had held a virtual monopoly of the imperial title, and by marriages and annexations had acquired territories which made them the most important ruling family of Europe. Brandenburg became in 1700 the Kingdom of Prussia, which, by the end of the eighteenth century, had become a formidable military power. After the defeat of Napoleon Germany was formed into the Germanic Confederation, with Austria and Prussia as two of its members. As both had become Great Powers, it was inevitable that they should become rival states for the ultimate control of Germany.

Growth of Russia

While the national states were developing in western and central Europe, the lands of eastern Europe had hardly reached the stage of urbanization. Russia, more Asiatic than European, was still a land of serfs and tyrannous overlords when, after the fall of Constantinople in 1453, the Grand Duke of Moscow claimed that the crown and title of the Eastern Cæsar (or Tsar) should be transferred to himself. Peter the Great, Tsar from 1689 to 1725, determined to make Russia a European Power. After conquering Sweden he gave Russia a coastline and built a new capital, St. Petersburg, on the Baltic coast. Between Russia and central Europe lay the anarchic feudal kingdom of Poland, while to the south and south-west lay the Turkish Ottoman Empire, spread over the Balkans and extending along the northern shores of the Black Sea. It was the work of Catherine the Great, Empress 1762-1796, to defeat the Turks, extend Russia to the Black Sea, and to arrange the partition of Poland between Russia, Prussia, and Austria. After the third of such unscrupulous partitions Poland had disappeared from the map and Russia had to be recognized as a European Power. The opportunity to enter actively the European arena came with the Napoleonic War, and, in 1807, at Tilsit, the two emperors, Napoleon and the Tsar Alexander I, met to divide the world between them.

Five years later Napoleon was retreating from Russia with the tattered remnants of his defeated army; two more years and Alexander was sharing the honours of victory at Paris and later at Vienna with the representatives of Austria, Prussia, and Britain. These four nations, joined by France in 1818, formed in the nineteenth century the Concert of European Powers.

Of these five nations, three were ruled by despotic monarchs, France had but temporarily repressed her revolutionary urge, and England, afraid of the agitation which was expressing the discontent of her own peoples, had a repressive and reactionary government when Europe settled again to peace after 1815. Though Britain soon withdrew her support from the scheme whereby the Great Powers were pledged jointly to intervene in any country where the existing order was threatened by popular uprising, the remaining Powers were strong enough to maintain a sufficiently reactionary and repressive régime to make further revolution inevitable. In the 1820's there were revolutions in Greece, southern and northern Italy, Spain, and the Spanish colonies in South America; in 1830 and again in 1848 revolutions spread from France, finally to overthrow the system of joint intervention which had imposed its reactionary authority on Europe for a generation. France became for the second time a republic, but four years later her President, Louis Napoleon, adopted the title of Emperor Napoleon III.

Unification in Italy and Germany

In Italy the political genius of Cavour and the military exploits of Garibaldi broke the temporal power of the Popes and unified the Italian states; by 1871 Italy had welded herself into a kingdom under Victor Emmanuel II of the House of Savoy. Prussia had driven Austria from the Confederation in 1866, and, after defeating France in 1870-1871, created the German Empire. The Prussianization of Germany by "blood and iron," the work of Bismarck, had been accomplished, while the adoption of the title Kaiser, the German form of Cæsar, for the new ruler of Prussianized Germany, was significant of the ambitions of this military state.

British Industrial Revolution

These great changes in the structure of nineteenth-century Europe gave Britain ample opportunity to develop her economic revolution undisturbed. We have already observed that in the eighteenth century the British Government had, in effect, passed under the control of the moneyed classes, and that a vast trade had begun to develop between Britain and the outposts she had established in the Far East and in America. The economic policy she had accepted, the Mercantile Policy, was based on the belief that a monetary profit was the only criterion of value. This implied that there should be a maximum output for export and a minimum importation, so that there should be a balance in gold. This miser-like policy, which kept the mass of people poor, implied also the capitalization of British production.

The capitalization of farming and its rapid and scientific development were followed by the capitalization of the cotton industry, while the invention of spinning and weaving machines stimulated the production

first of cotton goods and later of other textiles. The invention and improvement of the steam engine and its application to the pumping of water from mines, and later to the working of bigger and still bigger machinery, led to the development of Britain's coal and iron resources. By the beginning of the nineteenth century England had become an industrial nation of specialized manufactures, concentrated near the coalfields, with smoke-grimed towns sprawling round the mills, mines, and factories of the Midlands and industrial North.

This enormous increase in the production of wealth did not for a long time improve the conditions of life for the workers. Wages were incredibly low, prices of food were kept high by import duties which included a prohibitive corn law, children and women were employed in mines and factories under appalling conditions, and all attempts of workers to combine for the purpose of improving their conditions were repressed.

Though repressed, labour was not silenced, and the spark of human kindliness which is never quite extinguished flickered and sometimes flared in Parliament itself. The demand for the reform of Parliament, for the enfranchisement of the middle class and the representation of the industrial towns, could not be delayed after 1832, when the great Reform Act was passed. But the subsequent reforms were disappointing, and the Chartists demanded the parliamentary representation of the working classes and manhood suffrage. They were ridiculed, but their demands were not forgotten. Gradually the free trade policy of Peel and Gladstone, the development of railways, and the generally increased prosperity, softened the worst abuses, and the further extensions of the franchise in 1867 and 1885 were followed by far-reaching social reforms and the recognition of trade unions.

It was during the last third of the nineteenth century that Britain suddenly discovered that the virtual monopoly of world trade which she had so long enjoyed was being effectively challenged by nations which had begun to develop their resources and to become industrial nations after the fashion of the United Kingdom. The new Germany was already a formidable and jealous competitor, and the United States hardly less so. The age of industrial international rivalry had begun, a rivalry embittered by the fact that Britain had created a world-wide empire which it was wrongly assumed would provide exclusive markets for British goods and an adequate source for all Britain's needs. This, then, seems a suitable moment to glance at what has been occurring overseas during these four centuries of European development.

Colonization of America

The New World on which Columbus stumbled was an almost empty land. Red Indians, still in the tribal hunting stage, wandered near the forest edge in the northern continent. In the mountain strongholds of Central and South America ancient civilizations had survived, with powerful priesthoods, elaborate religious ceremonial, and using ornaments and vessels of gold and silver. The Spanish conquest of these regions, as that of Mexico by Cortes, or of Peru by Pizarro, or of

Chile by Almagro, brought easy wealth to Spain, and laid the foundations of Latin America.

In the northern continent English settlers, some traders, others refugees from religious persecution, founded colonies along the eastern coast, and separated by the Appalachian Mountains from the French settlers who had penetrated along the St. Lawrence valley into the interior. By the Georgian period there were thirteen British coastal settlements extending from the Puritan New England colonies in the north to the cotton plantations and convict stations of the Carolinas and Georgia in the south.

Development of the U.S.A. and Canada

The British mercantilist policy of the eighteenth century included the restriction of the economic development of these young colonies, particularly the industrial and commercial activities of the New England colonists. A series of Navigation Laws restricted their exportation of named goods to British ports, and young industries, such as the manufacture of fur hats and copper smelting, were forbidden. The resentment felt by the colonists against the country from which the ancestors of these particular ones had fled through persecution, had to smoulder unexpressed until the menace of French attack had been removed by Wolfe's conquest of Canada in 1759. Continued repressive measures persuaded the colonists to declare their independence (1776). The unsuccessful war Britain waged against them ended in 1783 when the new and independent nation of the United States was born.

Loyalists from the United States and emigrants from home began to add to the population of the six Canadian colonies which were all that remained to Britain after the formation of the United States of America; they were Newfoundland, New Brunswick, Nova Scotia, Prince Edward Island, and Upper and Lower Canada. In 1839 Lord Durham, sent out to investigate the economic and political discontent of the colonists, advocated, amongst other recommendations which were embodied in the Act of Union of 1840, the union of Upper and Lower Canada and the gift of fully responsible self-government. The success of this experiment is the germ from which the British Commonwealth of Nations has grown. In 1867 the British North America Act created the Dominion of Canada by the federation of the four provinces of Ontario (Upper Canada), Quebec (Lower Canada), New Brunswick, and Nova Scotia. In 1873 Prince Edward Island joined the Dominion. Newfoundland still remains a separate colony.

Both the United States and Canada spread rapidly westwards, across the prairies which might well be the granary of the world, and into and beyond the Rockies to the Pacific coast. Only once was the union of the states threatened, when the claim of the southern states to secede arising out of the question of slavery led to the Civil War of 1861-1865. The victory of the northern states meant the preservation of the union and the emancipation of the slaves. Round the Great Lakes have grown vast industries, fed from the inexhaustible resources of the United States and Canada; transcontinental railways connect these centres and the Atlantic ports and Pacific ports.

The opening of the Panama Canal in 1914 provided another means of communication between the Old World and the New.

The British in India

In India, the long struggle between the French and British settlers had ended in the supremacy of the British East India Company. As a result of Clive's victories over the French and their native allies, the trading company had become a Sovereign Power in the Ganges Valley, with responsibility to no one. The worst abuses consequent on such irresponsible authority wielded by traders were mitigated by the work of Warren Hastings, appointed by the British Government as the first Governor-General in 1774. It was the policy neither of the British Government nor of the company's directors that the traders in India should do anything other than trade, but each new Governor-General found conquest thrust upon him. So rapidly grew British responsibilities in India that in 1833 the trading function of the company ended and it was converted into an instrument of government. Periods of peaceful reform alternated with further acquisitions of territory until Lord Dalhousie, Governor-General from 1848 to 1856, conceived the idea of a British Empire in India, which was to have all the benefits of Western civilization. Transport was improved, telegraphy introduced, a postal system organized, canals constructed, new industries introduced, ports and harbours reconstructed, scientific methods applied to forestry, methods of food conservation and distribution planned to relieve famine, and the increased use of the English language encouraged. In a decade Indian trade was doubled, and Dalhousie retired from office expressing the belief that India was launched on a long career of peaceful development. Yet in the following year the Indian Mutiny broke out in the regiments stationed at Meerut, to find support from many of the educated Hindus who preferred their own civilization to that of the West, and from those alienated by Dalhousie's territorial annexations.

The suppression of the mutiny was followed by the abolition of the company and the assumption of direct control by the British Government. In 1877 Lord Beaconsfield (Disraeli) persuaded Queen Victoria to assume the title of Empress of India, and a Durbar of Indian princes was held in her honour. Another, in 1903, celebrated the accession of Edward VII in 1901 as King-Emperor of India.

European Penetration in the Far East

When in 1833 the East India Company lost its trading privileges, which had included Chinese traffic, this trade passed into the hands of private operators who cared nothing for the scruples and regulations which had disciplined the company's servants. China had forbidden the importation of opium, which the company had hitherto sold to China in return for tea, silk, and porcelain. The defiance of this ban led to the seizure and destruction of vast quantities of opium stores by the Chinese and the demand that the traders should be punished. The dispute led to war (1839-1842) and to the cession by China of Hong Kong to Britain, and to the admission of European traders to the Treaty Ports of

Canton, Foochow, Amoy, Shanghai, and Ningpo. A second war led to the opening of the port of Tientsin to British trade (1860). Other European countries were already developing "centres of interest" in the Far East. France was established in Indo-China, Annam, and Tongking; Russia had seized Amur; the Treaty Ports resembled European cities. Japan, impressed by the obviously superior efficiency of European and American methods, opened her ports and towns to American and European experts, and in a decade advanced into an industrial state organized on typically Western lines.

Australia, New Zealand and South Africa

To the south-east of Asia lay the almost empty land of Australia, whose barren-looking northern coastline had attracted only sporadic and half-hearted interest even from the Dutch settlers of the East Indies. That the south-eastern corner was far from barren was discovered by Captain Cook on the first of his great voyages (1768-1771), and, after the loss of the American colonies, Tasmania or Van Diemen's Land and south-east Australia, renamed New South Wales, were selected as convict stations. From these and free settlements, as at Adelaide, Melbourne, Brisbane, modern Australia has grown. The opening of the Ballarat goldfield in 1851 brought an inrush of immigrants; from 1800 to today Australia's population has increased from five thousand to seven and a half millions, most of whom are concentrated in the east.

In 1901 the six states—Western Australia, Tasmania, South Australia, Queensland, New South Wales, and Victoria—united to form the Australian Commonwealth.

It was not until the 1830's that colonization of New Zealand began, and the islands were formally annexed in 1840 by Britain. The Governor landed only a few days before the arrival of a French squadron! A long struggle with the native Maoris lasted until about 1870, after which date the colony began to develop rapidly. In 1876 the various administrative areas—Auckland, New Plymouth, and Wellington in North Island, Nelson, Otago, and Canterbury in South Island—united to form the Dominion of New Zealand.

In the seventeenth century the Dutch had begun to settle in the attractive land of South Africa. One of the results of the Napoleonic War was that this Dutch colony passed into British possession, and within a few years some thousands of British had sailed to the Cape. Quarrels between the British and Dutch or Boer settlers led some of the latter to trek to new settlements, and from the scattered farms they established grew the colonies of the Orange Free State, the Transvaal, and Natal. The rapid development of Cape Colony led to the grant of a Legislative Assembly in 1854, and to self-government in 1872.

Trouble with the Boers began to be serious with the discovery of diamonds at Kimberley, which both the British and the Dutch claimed to lie in their territory, and with the discovery of gold in the Witwatersrand, or "the Rand," in 1885. The Rand, which was Transvaal territory, was rapidly invaded by gold-seeking adventurers from most parts of the world.

Soon these *Uitlanders* outnumbered the Dutch population of the Transvaal, and the town of Johannesburg, built by the goldminers, grew into South Africa's largest town.

Meanwhile, Cecil Rhodes, the Prime Minister of Cape Colony, had begun to develop the land now called Rhodesia, where a chartered company was opening mines and building roads and railways under the protection of a small army whose function was to maintain order. It was this army which the *Uitlanders* invited into the Transvaal when the studied persecution by the Boer population and their President, Kruger, became intolerable. The small force, under Dr. Jameson, was defeated, and both Rhodes and Jameson were disgraced by the British Government which had had no previous knowledge of the raid. Encouraged by the Kaiser, Kruger took up the cause of the Boers generally for the possession of South Africa, and war between them and the British began in 1899. After an unexpectedly severe struggle the British defeated the Boers, compensated them for their losses, and promised self-government to the Dutch colonies which were incorporated in the British Empire. The Union of South Africa was completed in 1910, and General Botha, a Boer, was the first Prime Minister. Southern Rhodesia received responsible government in 1923; Northern Rhodesia remained a Protectorate.

Partition of Africa

As the nineteenth century began to draw to a close, the nations of western and central Europe, having at last more or less settled their internal problems, suddenly awoke to the realization that Britain had established colonies, protectorates, and trading outposts in every corner of the world. Paradoxically, it was only at the same moment that Britain began fully to appreciate the significance of her "empire." An undignified imperial scramble, for which Africa offered the only available field, left France with Algiers, the western and central Sudan, the greater part of the Sahara, and a share of the Equatorial forests. Italy claimed Tripoli and divided Somaliland with Britain. The Congo basin fell to Belgium. German Tanganyika was the only territory from Egypt to the Cape which was not either British or under some measure of British control; Germany's other territory was German South-West Africa. Farther north on the west coast Nigeria was made a British Protectorate, while Gambia, and the Gold Coast, old slaving stations, were also British. The controlling influence over the Suez Canal had passed to Britain when Disraeli purchased the Khedive's shares in 1875.

This bare outline of the process of oversea expansion, a process to which Britain has made the greatest contribution, rather obscures the most important essentials of the story. European Powers hold the view that Britain has world-wide *possessions*, which she rules to her own material and political advantage; but the idea of a British Empire ended with the World War of 1914-18. In its place the idea of the British Commonwealth of Nations, of which the Dominions are politically and economically independent and equal in status to the United Kingdom, was conceived. The idea reached its fulfilment with the report of the Balfour

Committee of the Imperial Conference of 1926, when the United Kingdom and the Dominions were defined as "autonomous communities within the British Empire, equal in status, in no way subordinate one to another in any aspect of their domestic or external affairs, though united by a common allegiance to the Crown, and freely associated as members of the British Commonwealth of Nations." This conception was given constitutional expression in the Statute of Westminster, 1931.

First World War

Conspicuous among the many factors which combined to cause the World War of 1914-18 were international greed and rivalry, both imperial and economic, jealousy of Britain's empire and trade, particularly on the part of an ambitious Prussia, belief that Britain's plea for friendly international collaboration was sheer hypocrisy in a nation so well satisfied, and confidence that a complaisant democracy, which would hesitate to make war, would if driven to it be content to muddle through it. The obvious threat of the Triple Alliance of Austria, Italy, and a re-arming Germany dragged Britain from her long isolation to seek the alliance of her old enemy France and Tsarist Russia, which, already humiliated by Japan (1904-1905), was herself on the verge of collapse. There is little point in following the war. Italy, hopeful for better spoils, deserted the Triple Alliance and joined the Allies, who were reinforced by the British Dominions, other imperial units, and later by the United States, and had the advantage of Britain's unbroken sea supremacy. By 1918 the brittle hardness of a Prussianized Germany broke before the more resilient strength of the democracies.

Birth of the U.S.S.R.

In 1917, bread riots in St. Petersburg developed without plan into the revolution which overthrew the Tsardom and established a republican government under Kerensky. Lenin, leader of the Bolshevik or extreme section of the Communist Party, returned from European exile to denounce the new government as a bourgeois affair and, after a bloody civil war, established himself as Dictator, destined to carry out the most astonishing political and economic revolution in history.

The political structure of the Union of Soviet Socialist Republics, a hierarchy of soviets or councils, was essentially the work of Lenin. The base of the political pyramid consists of local soviets, representing the villages, small towns, or parts of towns. From these are elected representatives who form the soviets of larger areas, the Oblasts and the Rayons, from which in turn the republican soviets are chosen, and so on to the apex of the pyramid, the All-Union Congress of Soviets, with its Central Executive Committee and Council of People's Commissars. This political machine is worked by the Brotherhood or Order known as the Communist Party.

After Lenin's death in 1924 the power was shared by Stalin, Zinoviev, and Kamenev, a triumvirate opposed by a section of non-compromising communists led by Trotsky. In 1927 Stalin expelled Trotsky from the party and became Dictator of the U.S.S.R. Stalin's main work, carried out by means of

the First and Second Five-Year Plans (1928-1938) was to plan for Russia a new national economy, and to make Russia capable of defending herself against possible invasion. What was accomplished was little short of miraculous.

Europe after 1918

In the 1920's, the nations which had emerged so recently from a World War were already drifting into further trouble. The peace treaties were to be based on the Four Principles and Fourteen Points which President Wilson of the United States of America had proposed. These admirable and idealistic conceptions included the sympathetic consideration of the interests of peoples and states, freedom of the seas, of trade, and of nations to develop in their own way without interference; they included the reduction of armaments, the restoration of territory and the formation of a League of Nations with machinery for the peaceful settlement of international disputes. Only the League survived, and that without the co-operation of the United States, with no means of adequately enforcing its decisions, and—its greatest weakness—with little sincerity on the part of its wealthier members when facing problems which demanded, for their solution, some sacrificial redistribution of economic interests.

Rise of the Dictators

Germany, by the Treaty of Versailles, lost territory, her merchant fleet, and her colonies. Deprived of resources, she had to pay a huge indemnity. Whether the terms were too harsh or not harsh enough is of less consequence than the fact that they were impracticable. In order to pay, Germany had to be reconstructed as an economic Power. Her complete financial collapse, together with the feeling that the loss of German markets was harmful to British and United States interests, persuaded the United States, with more money than she could profitably invest, to lend money to Germany. A humiliated but arrogant Germany, dependent on foreign loans, convinced that the Allies were weakening towards her, encouraged to believe that even in France fear of the "Bolshevik menace" was creating advocates for a strong Germany, and increasingly persuaded that the factors which had led to her defeat in 1918 were avoidable—such a Germany was fertile ground for the growth of nationalist parties determined not only to regain all that had been lost, but to carry to a successful conclusion the policy of conquest which had failed under the Hohenzollerns. The leader of the most important of these parties was Adolf Hitler, who had become so powerful by 1933 that Hindenburg, the aged President, had to confer the Chancellorship on him. In 1934, on the death of Hindenburg, Hitler seized the Presidency and retained the Chancellorship, adopting the title of *Führer*.

Most of the growing sympathy for Germany, particularly the tendency to support her economic and imperial claims, was alienated by the methods of the National Socialist Party which had placed Hitler in power. Little attempt was made to disguise the Nazi policy of making Germany a state wholly devoted to the waging of a successful war, a totalitarian policy which bent production, education, the

press, the radio, everything, in fact, to this end.

A similar military despotism had been established in Italy by Benito Mussolini. Italy had emerged from the First World War disappointed, and conscious of a feeling of national inferiority. The feeble government was incapable of controlling the innumerable elements of discord which were reducing Italy to chaos, and the view that democracy was an inefficient form of government gained adherents. Mussolini, head of the Fascists, a military and nationalist party, seized power in 1922, re-established order, and planned to make Italy an industrial and imperial Power to be feared.

The vigorous re-armament of Germany and Italy was justified by the Nazis and Fascists on the ground that Europe was endangered by the threat of communism, and it is undeniable that fear of communism, particularly in France, but to some extent also in Britain, obscured the main purpose of German and Italian militarism. Many believed that a war between the forces of communism and capitalism would ultimately be inevitable, and the impression that it was even imminent was encouraged by events in Spain. In 1931, a revolution overthrew the Spanish monarchy and the Dictatorship which sheltered under it, and established a republican government of liberals and socialists. The declaration that Spain was a workers' republic and the professed internationalism of the government looked dangerously like communism. With the formation of an Anti-Marxist League in 1933, Spain drifted rapidly into the civil war which began in Morocco in 1936, General Franco leading the reactionary party. That the war should have developed into the horrible internecine struggle it did was due to the intervention of Mussolini and Hitler, and to the aeroplanes, armaments, money and men they placed at the disposal of Franco. The war was deliberately misrepresented as a struggle against communism, but only sixteen of the four hundred and seventy-three members of the Spanish parliament were communists. But to many it was the beginning of a grim fight between two irreconcilable social, economic and political creeds.

The Years of Aggression

Britain had shown some degree of sympathy for Germany. She had supported Germany against France in 1920 when France occupied Frankfurt-on-Main, and again in 1923-25 when France occupied the Ruhr. The world economic depression which followed 1929, after a period of artificially stimulated production, led Britain to regret the loss of European markets and particularly of German trade. Though Britain led the League in the application of economic sanctions against Italy, when with poison gas and aeroplanes she conquered a relatively defenceless people in Abyssinia, the decision of fifty nations not to supply Italy with arms and certain goods was robbed of much of its sting when iron, steel, coal, and oil were excluded from the veto. In 1935 Hitler, who had regained the Saar Basin for Germany by plebiscite, was openly re-arming Germany on an unprecedented scale. France, alarmed, signed a defensive treaty with Russia and appealed to Britain. Still optimistic, Britain, however,

signed a naval pact with Germany, granting Germany the right to build a fleet up to a third of the British strength, and thereby acquiescing in Germany's re-armament and violation of the Versailles Treaty. Encouraged, Hitler invaded the Rhineland in 1936, and met with no serious rebuff for this further aggression. Persuaded that defiance of the Great Powers was not as dangerous as might have been expected, Mussolini joined Hitler in 1936 to form the German-Italian Axis. Japan had reached a similar conclusion, and in 1937 began war on China.

The time seemed ripe for aggression. The League had proved impotent; the United States still held aloof; France was increasingly torn between fear of Germany and fear of communism; Russia was as yet an unknown quantity, and certainly had little cause to be friendly towards the Western nations; Britain was still intent on keeping the peace—she was certainly unprepared for war and her refusal to intervene in the Sino-Japanese War, though Japan was the unprovoked aggressor, seemed symptomatic. In March, 1938, Hitler annexed Austria to the Reich.

Second World War

That Germany intended to regain the Germanic parts of Czechoslovakia was apparent, and at last Britain began hastily to re-arm. The British and French Prime Ministers, Neville Chamberlain and Edouard Daladier, met Hitler and Mussolini at Munich, and accepting Hitler's word that no further aggressions were contemplated, recognized a "final" restoration of German territory which took from Czechoslovakia large areas of land. Chamberlain returned to England believing that he had "saved the peace." But six months later, in March, 1939, the rest of Czechoslovakia was seized by Germany. Poland, whose Danzig Corridor divided East Prussia from the rest of Germany, was the next obvious victim, and Britain and France, who had guaranteed her territorial integrity, declared war on Germany on September 3, 1939, two days after Nazi troops had crossed the Polish frontier.

Within a year Germany had overrun Poland, Norway, Denmark, Luxembourg, Belgium, Holland, and France. Italy, once the danger of reversal seemed remote enough, joined to play jackal to Hitler. Hungary, Bulgaria and Rumania joined the Axis. The British Commonwealth, after the dramatic evacuation of the British forces from the Continent at Dunkirk, was, for a year, left alone to defend itself and any surviving hopes for freedom unaided. That Britain, inspired by the Chatham-like Churchill, survived the aerial bombardment of 1940-41 and the more dangerous U-boat attacks on her shipping, that Germany should have broken her pact with Soviet Russia and that her armies, after penetrating into the heart of the Soviet territory should have been rolled back from Stalingrad, that the British should have defeated the Afrika Korps at Alamein, could hardly have been expected, yet the truth is so recent that the story needs no re-telling. Nor is there space to do more than chronicle the United States' entry into the war, under the vigorous presidency of Franklin D. Roosevelt, after Japan's treacherous sinking of the greater part of the

United States Pacific fleet at Pearl Harbour; the American and British triumphs in North Africa and Italy; and, with naval supremacy finally established, the British and United States landings in Normandy in June, 1944.

By the end of April, 1945, the British, United States and other allied forces advancing from the west, and the Russian forces advancing from the east had met on German soil; on May 7 Germany surrendered unconditionally.

Japan, although fighting a losing battle, might have maintained the struggle for many months, but the Allies unleashed a new and terrible weapon against her. After atomic bombs had devastated Hiroshima and Nagasaki she surrendered (on August 14) ere worse befell.

The United Nations

That the last view of humanity, in this brief survey of world history, should have to reveal the greater part of the world's peoples engaged in a war in which every conceivable scientific aid and human effort were devoted to the destruction of life, wealth, and the irreplaceable treasures of the past, with hatred, fear, greed, jealousy and the like still the most obvious motives of general human behaviour, is to make of world history a pathetic tragedy. If there were nothing to add, the record would be even more deplorable and humiliating.

But even in this gloomy age, when Need is elbowed out of sight by Effective Demand, and competition has grown unscrupulous, there are gleams of hope. There is a growing insistence, particularly amongst the people of the British Commonwealth of Nations, which includes the United Kingdom, and amongst the peoples of the United States, that the vision of a world's people in friendly and peaceful co-operation is not a poet's dream, but a practical possibility. Many times during the war the responsible representatives of Soviet Russia, the United States, and Britain expressed this ideal as the necessary basis of post-war reconstruction. The conversations at Dumbarton Oaks, in the autumn of 1944, proposed the formation of a United Nations Organization with the objects of maintaining international peace and security, the development of friendly relations among nations, the achievement of international co-operation in the solution of economic, social and other problems, and the provision of a central organization for the realization of these common ends. At Yalta, in the Crimea, Stalin, Churchill, and Roosevelt re-affirmed their adherence to these principles, and arranged for the assembly of an international congress at San Francisco, which commenced work on April 25, 1945, for the elaboration of the necessary organization. Unfortunately, the end of the European phase of the second World War on May 7, and of the Japanese phase on August 14, left a residue of fears, suspicions, contradictory aims and ambitions, and immediate problems, sufficiently disturbing to re-affirm the flimsy nature of the ideal. Nevertheless, the representatives of fifty-one nations met in London early in 1946 to establish the United Nations' Organization whose symbol (see Fig. 19), suggests the all-embracing unity and inter-dependence of the world's peoples.

There are, too, material and uncontrollable factors which must,

in time, necessitate some world-planned economy. The British Dominions, as yet with small but rapidly growing populations, are passing in varying degrees from the agricultural to the industrial stage of economy. Canada, the United States, and Latin America, with an increasing tendency towards the correlation of their already vast industrial output, are but little beyond the beginning of the development of their almost inexhaustible resources. Hydro-electric power is extending industrialization beyond the coal-fields, and European nations which, but recently, had an essentially rural economy, are already developing important manufacturing industries. In time the age of industrial rivalry must pass, because human development will reduce it to an absurdity.

Planning a World Economy

Some idea of the changing economic situation may be gained from the following statistics, which are based on the British Board of Trade Returns, unless other references are quoted. Before the First World War the United States was a debtor nation, but a nation which was reducing her vast indebtedness to the world by her developing industries and shipping service. After the war she was the world's greatest creditor, but she was what is known as an immature creditor, i.e. one which still is paying interest on old loans. A few years before the outbreak of the Second World War America had become a mature creditor, with an enormously expanded industry. From 1935 to 1937 the exports of the United States increased by more than 1,000 million dollars (rather more than £200 million), an increase of nearly a third. In the same years Canada's exports increased by 39 per cent. By 1929 Canada had become one of the six creditor nations of the world. The others were the United States, the United Kingdom, France (the three matured creditors), Sweden, and Czechoslovakia (see Aylmer Vallance: "Foreign Trade and the Exchange").

The importance of this to the United Kingdom becomes obvious when it is realized that Britain ceased to be a creditor nation in 1931! In 1929, after buying goods which cost the astonishing total of £1,220 million, for which she paid by exported goods (£839 million), by shipping and other invisible exports (£210 million), and by interest on invested loans and other receipts (£274 million), the United Kingdom was left with a credit balance of £103 million. Adding £15 million's worth of imported gold bullion, Britain had £118 million available for foreign investment. In 1931 exports, shipping income and receipts from investments had so shrunk that the commercial year ended with a debit balance of £69 million. By 1936 the balance of payments showed a deficit on the year's trading of £246 million, and, if the heavy export of gold is excluded, of £19 million.

The Government White Paper issued in November, 1944, giving statistics relating to the war effort of the United Kingdom showed that during the war overseas assets to the value of £1,065 million had been sold and that liabilities abroad amounting to over £2,300 million had been incurred.

Already, therefore, the United Kingdom, with enormously increased debts, reduced shipping,

lost or withdrawn investments, and with more numerous and more formidable industrial competitors, is compelled to regard some form of planned world-economy and international collaboration as necessary for her own economic security. There can be no doubt that, in time, the necessity will thrust itself inevitably upon all nations, however unwilling they may be to recognize it.

More or less at one in their denunciation of the inherent attributes of a capitalist economy, socialist theories differ essentially on the question of the extent to which a national economy should be state controlled. The governments of several European countries included among their plans for post-war reconstruction varying degrees of nationalization of banking and the larger industries. The British Socialist Government, in particular, introduced a wide programme of nationalization which included the coal mines, the railways and the Bank of England.

Theoretical communism, to which Russia's astonishing and gigantic experiment is the nearest approach, advocates an absolute control by the state. Logically this implies that all the national sources of wealth, material or human (and human sources include, in addition to labour, such capacities as skill, imagination, ingenuity, organizing ability, and the like), together with the goods produced, belong to the nation as a whole. This in turn implies that the controlling agency must be genuinely and disinterestedly a nationally representative body.

Without referring to the many other and less extreme doctrines directed towards social and economic readjustments on a national scale, it is clear that there is a vastly changed attitude in the world today towards the factors involved in the production and distribution of the world's wealth. Amongst the workers there are a greater knowledge, a developing intelligence, and a greater understanding of the meaning of social freedom. There is a healthy tendency to put even such accepted concepts as democracy into the dock; to ask: "What is democracy?"; to accuse it of "many faults, stupidities, and shortcomings," and to come to some rational conclusion about it.

Fig. 19. *Symbol of the United Nations, set up at San Francisco.*

The Gleam of Hope

There are healthy signs, and in them lies a gleam of hope. Moreover, even in this materialistic age, when there seem to be so many who scoff at idealism as a sham and hypocrisy, who believe Man to be wholly selfish, who contend that security depends only on force, that love is a glandular mechanism, and that there is no value other than the practical, even now there are poetry and music, and young poets who have said, in a dozen lines, what pages of the historian's prose can only suggest.

Fig. 1. *Clock Tower of the Houses of Parliament, symbol of British democratic government By night a light in the tower tells the citizens of London when the House is sitting The name Big Ben, often applied to the Clock Tower, belongs to the great bell on which the hours are struck*

CHAPTER 8

AN INTRODUCTION TO POLITICS

Scope of Politics. Forms of Government. British Constitution. Liberal Party. Conservative Party. Trade Unions. Chartism. Co-operative Movement. Labour Party. Karl Marx. Fascism. National Socialism. Communism. British Parliament. The Crown. House of Lords. House of Commons. The British Cabinet. Party Politics. Parliamentary Procedure. The Civil Service. Government Offices. Local Government. Rates and Taxes. Government of London. Rate Allocations. Derating. Statute of Westminster. League of Nations. United Nations.

POLITICS is the art and science of government and the administration of public affairs. This is a minimum, not a maximum, definition. Some authorities (G. D. H. Cole being one) hold that in the near future "politics and economics will cease to be thought about as mainly separate problems, and will present themselves as one and the same problem." The socialist will subscribe to this; the non-socialist not necessarily so, although he will admit that in these days of public corporations, of such undertakings as the London Passenger Transport Board and the Central Electricity Board, of direct trading by local authorities and their employment of direct labour for building and other purposes, facts supply an increasing amount of support for this view. Considerations of space demand that the narrower and less controversial definition shall be accepted here.

Many who readily associate politics with Big Ben (see Fig. 1) and a borough town hall's council chamber assume that the work done by elected representatives in the parish hall of a village or in the room behind the bar of a hamlet's one inn is too trivial to be described as politics. Nothing of the kind. The decision to erect a lamp-post in Little Stodgham is, if the cost be voted from public funds, as much politics as the Budget a British Chancellor of the Exchequer opens in April; the authorized purchase of a Union Jack and a string of bunting in Great Stodgham is, when public funds bear the expense, as much a political act as a debate in the House of Lords—and often of more practical significance.

It is frequently a Briton's proud claim that the British are the most politically expert people in the world. This, like most national boasts, is an exaggeration of a truth. Yet, truth in essence it is. The Dominion Governments, the governing bodies of the Colonial Empire territories, the United States Federal and State Governments: all these are based on the principles and to a large extent on the practices of democracy as it is known in Britain.

Before democracy is defined, here are brief definitions of forms of government with which men have experimented in the past, and with most of which they are still experimenting today:—

Monarchy is that system of

government in which supreme rule is invested in the person of a single (usually hereditary) sovereign or monarch. A king is not necessarily a monarch in the strict sense of the term since, as in Britain, Denmark, Norway, Sweden, Belgium and Holland, his sovereignty is largely nominal, the reality of sovereign power being possessed by rather than shared with popular bodies in the shape of parliaments. Such monarchies are often known as limited monarchies and can with some accuracy be described as crowned republics. Monarchies of the absolute type ceased to exist in Europe after the First World War.

Republic is that form in which the ruler, usually called president, is elected by the citizens, ordinarily (as in the United States) for a definite term. Both in classical and in modern times the term has been very wide and very vague. Thus Rome until the time of Augustus was still known to the Romans as a republic: in this connexion it may be mentioned that the Latin term *res publica* and the English word commonwealth are almost exactly synonymous. Among modern republics, while the United States of America and Switzerland are careful to limit presidential powers and to resist actively any president's attempt to expand them, the rulers of the Union of Soviet Socialist Republics (U.S.S.R)., Spain, Turkey, and several of the Latin American republics have powers of a varyingly dictatorial nature. Britain provides an almost perfect historical illustration of the anomalies and ironies of governmental facts as compared with governmental theories. During the brief Protectorate period she had, chiefly because of Charles I's insistence on the "divine right of kings," rid herself of her monarchical form of government. Yet no British ruler has been more nearly a dictator than the Protector himself.

Oligarchy. This is the term given to government by the few, and that government unrepresentative in that the oligarchs cannot be dismissed constitutionally by the people they rule. Famous historical examples are provided by the republics of Venice and Genoa. By the sixteenth century the Venetian Council of Ten had made the Doge a purely nominal ruler and, with the aid of an elaborate spy and secret-police system, had brought the entire resources of the state under their tyrannical rule. No considerable state today has a purely oligarchical government, although, prior to her defeat, Japan was a modern example. The view that the Two Hundred Families ruled France under the Third Republic may have a degree of truth in it; yet France remained in fact a republic.

Theocracy is government by priests claiming to represent God and to interpret His will: Tibet with its Grand Lama is a notable example. The best historical example of a theocracy is the system by which the Jewish people are ruled—a people without a country, state, king, or president, or any formal parliamentary institution.

Evolution of Democracy

In its original form democracy was that type of government in which every citizen had a separate voice, in the all but literal sense of the word *voice*. The most notable example of this was provided by the city states of ancient Greece where the number of citi-

zens (not including women, helots, slaves and foreigners who performed the manual work of the state) was so small that all could assemble in one place and conduct their public business with no delegation of authority. When the number of citizens had so increased that no such assemblies were possible, representative democracy had to be invented. Elected representatives were responsible to their electors. A representative democratic government, therefore, is no oligarchy: in a democracy the right of the people to dismiss their government is fundamental, for only by this safeguard is it possible to ensure, in the famous words of Lincoln (see Fig. 2), "government of the people by the people for the people."

The helots and slaves of Athens, Corinth, Megara and other Greek states had their counterparts in the serfs of feudal times. As the Dark Ages passed, there were stirrings of discontent among serfs and peasants. Such pestilences as the Black Death (1348-1351) made the labourers, bond and free, conscious of their value in and to the community. On the Continent there were risings among the Jacquerie (French peasants) in 1358, and the Ciompi (Florentine weavers) in 1378. In Britain Wat Tyler and John Ball led the peasants' revolt of 1381. John Wycliffe made a popular translation of the New Testament in about 1380-1382 and the invention of printing at the beginning of the fifteenth century carried the Jewish scriptures as well as the New Testament's teaching to the peasants and town labourers. Old and New Testament alike are revolutionary both in matter and manner. On the Continent theo-

Fig. 2. *Abraham Lincoln (1809-1865), President of the U.S.A. 1861 to 1865, and champion of democracy.*

logical reformers like John Huss and Martin Luther (early fifteenth and sixteenth century respectively) found their supporters largely among the poor. In 1450 Jack Cade had led another peasant rebellion in Britain. These were all threads in the developing pattern of modern democracy. The French Revolution (1789) gave that pattern sharper lines and richer colours. For by it French serfdom was abolished; liberty, equality and fraternity were no longer merely abstract principles to be argued over, but political issues for which men fought and died.

The British Constitution

The ideas behind the French Revolution killed absolute monarchy, and this was pure gain for democracy. At the same time these ideas somewhat exalted the principle of republicanism, which the American Revolution had already

successfully introduced into the New World. Today, Britain's limited monarçhy is essentially democratic as the German republic of the Nazi State was not and, some contend, the republican form of government of the U.S.S.R. is not.

British forms of government have been copied throughout the world. Yet Britain has no written constitution, such as those of the United States, the U.S.S.R. or France, and itself preserves an anomalous mixture of the old and the new, of the twentieth century and its universal suffrage and of the Middle Ages and their feudalism. A British coronation nauseates a republican purist. How can this apparent contradiction be explained?

British political progress has been evolutionary, not revolutionary. The country's constitutional history has been a story of gradualism, to adopt the term used by Sidney Webb in his address to the Labour Party Conference in 1922, as a description of the Labour Party's philosophy of socialism. It needed almost exactly a century from 1832, when the first Reform Act was passed, for the widening of the franchise to reach a point at which the poor as well as the rich, women as well as men, had the right to ballot on equal terms.

Rise of Liberal Party

Much of the electoral progress made goes to the credit of the Liberal Party, successors of the earlier Whigs. The rise of such a party was inevitable, being determined not by accident or chance or the advent of some leader of genius but by the country's new needs due to social and economic changes. During the late eighteenth and early nineteenth centuries the time lag between such changes and the adjustment of the country's form of government to the facts of these developments was greatly accentuated. Thus, Birmingham from being, as Leland describes it, "a good market town of which the beauty was one principal street of a quarter of a mile long, inhabited by smiths that use to make knives and all manner of cutting tools; and many lorimers that make bitts, and a great many nailors," had by the middle of the nineteenth century become a great city of 250,000 souls. Yet Britain, with high tariffs and other multifarious regulations restricting trade, was attempting to muddle through as though it remained the primarily agricultural and pastoral country of the past. Moreover, there was not one but a number of such cities, and in each of them industry and population were leaping ahead.

Liberal Policy

He who would understand British Liberalism, its strength and its weakness, would be well advised to read something of the work of the eighteenth and nineteenth-century political thinkers and writers. Two nutshell quotations must suffice here. Ricardo's: "the natural price of labour which is necessary to enable the labourers to subsist and to perpetuate their race without either increase or diminution" indicates the *herrenvolk* attitude of the industrialists who were increasingly supporting the Liberal Party and its policy of cheap food and low wages. Adam Smith's: "the individual aims only at his private gain and is led by an invisible hand to promote the public good," succinctly states the half truth implicit in Liberalism's cham-

pionship of political *laisser-faire* in industry; of active resistance to interference by the state in trade and in matters of wages and their regulation; of free trade as opposed to the tariff system, and of industrial individualism that verged on the anarchical.

Liberal thinkers prepared the way for Liberal politicians. William Huskisson, as President of the Board of Trade, in 1823, relaxed the navigation laws and the Reciprocity Acts, and reduced many

Fig. 3. *David (later Earl) Lloyd George (1863-1945), British Liberal leader; Prime Minister 1916-1922.*

protective duties, especially those on textiles. Cobden and Bright by their energetic propaganda for the abolition of agricultural tariffs carried on Huskisson's work; in 1846 the Corn Laws were repealed, and Liberalism could claim that one of its primary objectives, cheap food for the workers, had been gained.

Its other objective, low wages and long hours in the factories, was all too successfully reached. To read those classic accounts of conditions of labour and conditions of life to be found in the Webbs' works and in those of the Hammonds (notably, *The Town Labourer*, *The Country Labourer*, and *The Skilled Labourer*) is to realize that the cliché "wage-slave" is an exact description of the worker's lot during the years in which his labours were making England the workshop of the world and the country's employers the richest and most powerful among the world's ruling classes. Dickens, most liberal-minded writer of his times, both consciously and unconsciously indicted the fruits of British political Liberalism during its earlier heydey as no other has done.

It was not until its radical elements gained influence in the Liberal Party that that party developed a social conscience. Under its leader of genius, William Ewart Gladstone, it carried out a programme of parliamentary reform which has since achieved the democratic ideal of one citizen, one vote. Thus, while the 1832 Reform Act had abolished glaring anomalies in representation rather than extended the franchise, Gladstone's Ballot Act, 1872, by making the ballot secret gave reality to Disraeli's Reform Act of 1867. Again, Gladstone's own Representation of the People Act, 1884, gave the vote to two million rural workers and increased the electorate by two-fifths.

Liberal Achievements

Apart from the gradual extension of the franchise Liberalism's achievements, of which no man in his senses would deny the value, included the abolition of religious tests for entrants to the universities,

the establishment of popular education, the legalization of the trade unions, the inception of old-age pensions and of national health insurance, and the passing of the Parliament Act, 1911, which curtailed the powers of the House of Lords. With the last two of these the name of David Lloyd George (see Fig. 3), last of the great Liberal leaders, is inseparably associated, as is Gladstone's with the long Liberal struggle in the cause of Irish Home Rule.

The Conservative Party

As English Liberals inherited from the Whigs, so English Conservatives are successors to the Tories, a name by which they are still frequently known. The change of name was disliked by many Tories, especially those of the school of Lord Shaftesbury who accepted any reform the need of which was made clear, while they were themselves responsible for such reforms as the earliest Factory Acts. Nevertheless, the new name was adopted, and shortly afterwards the Conservative Party found a new leader and a new dynamic. That leader was Disraeli who stole much of the Liberal thunder, welcomed into his own fold the seceding members of the Liberal Party who, calling themselves Liberal Unionists, broke from their old allegiance on Gladstone's attempt in 1886 to give Ireland Home Rule. In 1895 the Conservative and Liberal Unionist organizations were amalgamated when Chamberlain and Hartington (Duke of Devonshire) entered the Salisbury Cabinet. With two brief interludes of government—office without power—by the Labour Party in 1923-24 and 1929-31, the Conservative Party as such, or as the dominant party in the various war-time coalition Governments, ruled the country between 1916 and July, 1945. Since 1922 the country's electoral choice has been between not Conservatism and Liberalism but between Conservatism and the Labour Party.

Rise of Labour Movement

British labour, significantly enough, made its first gropings towards organized action shortly after the early years of the French Revolution and before the Napoleonic bogy enabled the possessing classes to arm themselves with additional powers with which to crush the new workers' movement in its infant weakness. The Combination Act of 1799 forbade union and strike action and was followed by even more stringent legislation; during the 1812 strike by 40,000 weavers, the strike committee were imprisoned. Twelve years later the upsurge of working-class feeling had forced the repeal of the Combination Acts. By 1834 the Grand National Consolidated Union had attempted to organize British workers nationally. In this year, too, took place the deportation of the six Dorset labourers of Tolpuddle whose memory inspires Labour still.

The British working class as a whole is not familiar enough with the story of Chartism. That movement's manifesto, the "People's Charter" drafted by William Lovett in 1837, demanded:—

(1) Universal manhood suffrage.
(2) Vote by ballot.
(3) Equal electoral areas.
(4) Abolition of M.P.s' property qualification.
(5) Payment of M.P.s.
(6) Annual elections.

The Chartist march on London

Fig. 4. *Birthplace of a great movement: the Rochdale Pioneers' first co-operative shop, opened in 1844. The shop still stands to this day.*

to present the movement's petition to Parliament was, unlike the march on Rome by the Italian Fascists of some eighty years later, seemingly a failure. Whereas fascism was destined to be ignominiously destroyed, Chartism's successor, the British Labour Movement, has seen five of the six points become the law of the land, and in the Trades Union Congress has set up a workers' industrial parliament which no British Government, whatever its political colour, can now ignore.

Chartism declined not because it was weak or its cause poor but because for over fifty years Britain's triumphant industrialism made the country the world's chief supplier and the world's richest state. The national riches were, however, so badly distributed that in Disraeli's words, Britain "was one country but two peoples, the rich and the poor." One of the biggest factors which today modify this maldistribution of wealth came into being in 1844 when Charles Howarth and the Rochdale Pioneers in general inaugurated the first successful co-operative movement by setting up one small shop in the Lancashire town which gave its name to the Rochdale Co-operative Society (see Fig. 4). Here dividends were paid to members in strict proportion to the amount of their purchases, and the revolutionary step was taken of giving one member one vote, however large or small his holding of shares. The challenge to capitalist industry with its money-power principle went unrecognized: the Rochdale Pioneers remained small beer in the

eyes of the contemptuous magnates of the Victorian era. Within a hundred years their successors were to find themselves faced with the greatest single enterprise in the country, represented in Parliament by its own M.P.s, owning factories, docks, tea-plantations, a bank, an insurance company, and every kind of retail establishment; while by 1945 hotels and boarding-houses, summer holiday camps, cinemas and a theatre had passed, or were passing, into co-operative society control. Contrast this with the year 1864 when the Co-operative Wholesale Society was formed with a mere £1,000 as capital: with this petty sum the struggle began to make the movement independent of capitalist suppliers and secure against intimidation by their weapon of the commercial boycott.

In 1899 the Trades Union Congress joined with socialist organizations to form the Labour Representation Committee. In 1906 this became the Labour Party, returning twenty-nine members to Parliament in the election of that year, while in 1924 the first Labour Government was supported by 191 members in the House. The 1929 election saw Labour (with 287 members) for the first time the largest single party in the House, and for the second time responsible for the (minority) government. Majority government, with a clear majority over all other parties combined, came to the party with the General Election of July, 1945.

Independent Labour Party

The Independent Labour Party, now mainly of historical importance, was, when founded in 1893 by Keir Hardie, thus named in that it was a socialist body independent of the "Lib-Labs" of the Labour Representation Committee-to-be. For some forty years the Independent Labour Party was to provide the Movement with its spearhead, most of its intellectuals, and no small part of its dynamic. With the Fabian Society, formed in 1884 and memorable for the membership of Bernard Shaw, the Webbs, and H. G. Wells among others, the Independent Labour Party helped to broaden the Labour Movement so that, no longer standing for purely sectional interests, it had a national status and appeal.

Communist Doctrine

In the world of today no nation can afford to be as insular as Great Britain has been in the past. It is necessary then to put the British democratic idea into world perspective. This has been challenged by the ideas behind communism in Soviet Russia, behind national socialism in Germany, and fascism in Italy, and behind the revolutionary technological advances made by the capitalist United States of America.

How communism views capitalism can best be seen by a brief summary of the Manifesto of the Communist Party, the work of Karl Marx (1818-1883) and Friedrich Engels (1820-1895), published in 1847. In the manifesto Marx (see Fig. 5) stressed two points as important above the rest: the economic interpretation of history and the theory of surplus value. In his great work, *Das Kapital*, Marx elaborates both of these with a wealth of historical illustration and a cogency of argument of which no indication can be given here.

Communism's first demand of

any student of its philosophy is that he shall accept the dialectical principle. *Dialectic* is a term signifying no more than a particular form of intellectual analysis. It needs to be realized that Marx was primarily a philosopher, one of the few whose philosophy has become the basis of a form of government. Hence, when he analysed the process of historical changes and put forward in explanation the theory of historical materialism, he used the jargon terms of philosophy: thesis, antithesis and synthesis.

The heart of this theory is that codes of laws, systems of education, the conditions of morals and the level of art are not unrelated social phenomena, but integral parts of a social whole—human society; that the essential purpose of society is the supplying of Man's needs; that to satisfy these production is all-important; that when new methods of production are introduced, the relations of individuals and of classes are altered with a consequent change in laws, education, art, morals and the rest.

The Class Struggle

Marx's theory can be accepted or rejected; it cannot—with wisdom—be ignored. Up to a point, many philosophers of the past including Plato himself would have been interested in, and by no means antagonized by, Marx's conclusions. From this point Marx's development of his theory implies an inevitable, not optional, rejection of evolutionary socialism in favour of revolutionary socialism, with the use of force to end the class conflict in capitalist society and to end it with victory for the revolutionary proletariat.

A necessarily crude over-simpli-

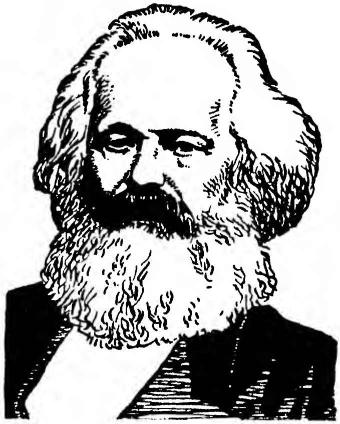


Fig. 5. *Karl Marx (1818-1883) author of "Das Kapital" and originator of the doctrine of communism.*

fication of Marx's views of the class struggle is all that can be attempted here. From the beginning, Man's history has, he held, been a story of class warfare, the exploiters pitted against the exploited. Labour has created all wealth, but the labourer is far from enjoying his full share of the wealth he has helped to create; for the bourgeois capitalist leaves him a wage sufficient for subsistence only, while the balance (the surplus value) is appropriated by the capitalists. The workers, with only their labour to sell, organize; to meet the threat of that organization the possessing classes increase their economic power by concentrating it into larger and fewer units and by employing more and still more machinery. The only solution is the overthrow, by force, of the possessors by the proletariat; the subsequent dictatorship of the proletariat—a transitional stage during which the workers will expropriate

some and liquidate others of the counter-revolutionary forces attempting to return to the *status quo*; and the establishment ultimately of the socialist commonwealth, a classless society in which private ownership of the means of production will have been abolished and the old conflict of haves and have-nots thus be ended.

This intellectually impressive theory is plainly not in accord with the British political tradition of compromise, evolution, gradualism —call it what you will—shared by the Left as well as the Right. The Marxist intellectual's retort to this is doubtless: "So much the worse for British political tradition!" Yet, as Marx himself would readily have admitted, a tradition with a thousand years of history behind it cannot be dismissed with a shrug of the shoulders. It remains to be seen whether the tempo of political change in Britain will be greatly accelerated by the effects of two total wars in one generation and by the deep impression made by the U.S.S.R. under its communist regime on the minds of most British workers, whether politically conscious or no. This then is the challenge of communism to the British idea of representative democracy.

The statement that to win the war against national socialist Germany Britain was herself forced to become a national socialist state is often made. As has been stated, the right of the people to dismiss their government is fundamental in representative democracy. Between November, 1935, and July, 1945, the electors had no opportunity at a general election to reverse the mandate given in the former year to a Conservative government on issues that have long since become academic. A short account of fascism, both the earlier Italian and the more recent German variety, is therefore necessary at this point.

Rise of Fascism

In Italy in March, 1919, Benito Mussolini organized under the name of *Fascio di Combattimento* some one hundred and fifty ex-servicemen. One of a number of similar bodies, in its first year it was an odd mixture of extreme patriotism and nebulous syndicalism. When the workers of northern Italy by revolutionary strike action in 1920 took temporary possession of the factories of the great industrial cities, *Fascio* was on their side. Early in 1921 Mussolini changed all this. Italian industrialists saw in the ex-editor of the socialist *Avanti*, in the founder of the patriotic *Il Popolo d'Italia*, a man of talent and energy who, having been bought once, might be bought again. So they bought, and Mussolini gave them good value for their money. He came out in support of private property and private enterprise; he denounced strikes, communism and socialism; he founded his Blackshirt squadrons on the model of the *manipuli* (companies) of the ancient Roman legions; he used these to smash strikes and to break up socialist meetings and processions. His movement gathered support: May, 1921, saw thirty-five fascist representatives, headed by Mussolini, in Italy's parliament.

In October, 1922, following the resignation of the government and an agreement made between Mussolini and the political parties of the Right, the fascists countered the general strike called by the Alliance

of Labour with the march on Rome. The king invited Mussolini to form a government, and on October 30 the fascists were in control of the country.

So much for the history of fascism's origins. It was conceived of opportunism and born of Italian post-war chaos. It did not grow out of a political philosophy as the communism of Soviet Russia grew out of Marxist socialism. It invented such political philosophy as it had to meet the needs of a personal dictatorship; it flourished on castor oil (administered to the opponents of the regime), on beatings-up, on imprisonment and on murder.

The Fascist State

For the Anglo-Saxon conception of a government that shall ensure the greatest amount of freedom to the greatest number, fascism substituted the precept that the state was supreme and that the individual existed only to obey the state in the person of its leader, its Duce, its Mussolini. The Italian sovereign remained, a puppet, a figurehead; the effective head of the state was Mussolini as *Il Duce*. It was he who nominated his Fascist Grand Council; it was that council which issued the list of 400 candidates; it was the 400 who, voted *en bloc* for or (by the few willing to risk castor-oil or worse) voted *en bloc* against, became the House of Deputies.

This, then, was the political framework of the so-called Corporate State. On the economic side the state again was supreme. Workers' syndicates were organized (by the state) on a regional basis; employers' syndicates, similarly state-organized, chose representatives equal in number to the workers' representatives: the two sections formed a corporation whose chairman was state-appointed. These regional corporations were co-ordinated geographically into nine national federations, and these were made subordinate to the State Ministry of Corporations. The regional corporations had jurisdiction over conditions of employment, notably hours and wage rates; and agreements reached had the effect of law Strikes and lockouts were illegal, and a provision was made that any dispute could be settled by magistrates sitting in special courts.

Whether such a system, worked by men of good will in a country where the state was not the Lord Panjandrum, could provide an effective governmental machine in the economic field is a matter for controversy, and in part the answer given would be dependent on the national temperament of the people concerned. It is certain that the Anglo-Saxon people and those of Scandinavia would find it repugnant to their existing principles embodied in the practices of collective bargaining, the right to strike, and the rest. It is still more certain that in the fascist Italy of the 'twenties and 'thirties this system was an elaborate fake, a device by which the owning classes safeguarded their own interests and trampled on those of the workers.

At this point one thing may be said with advantage. There is nothing holy or sacrosanct about democracy. Like any and every other principle of government it has to be judged by results: by whether or no it delivers the goods of freedom and economic prosperity to a free people. Its exponents too often

talk cant in support of it, speaking as if it were a kind of third table of the law handed by some political Jehovah to an English-speaking Moses to be the divine revelation to the Anglo-Saxon chosen people. Idealistic smugness can make the excellent content of the Four Freedoms itself suspect; while the moral rectitude and parochial egotism that would make the acceptance of political democracy by politically undeveloped peoples a criterion of merit is worse than a crime: it is the stupidest of blunders.

To return to the main theme: Italian fascism has now only an academic and historic interest, although even in Great Britain fascism under another name would receive the support of not a few of the privileged and the reactionary. In Italy its achievements included land drainage, marsh reclamation, the erection of many fine and often striking public buildings, a reorganization of the railways, and (in Libya) an efficient system of colonial settlement.

Whatever its merits or demerits, Italian fascism did have, on paper at least, some kind of governmental system to put forward, and in fact did construct some kind of political edifice, based though it was on the acceptance of the servile state by servile citizens and the destruction by torture and death of all opponents of the fascist state.

German National Socialism

For national socialism, the German form of fascism, no constructive political claims can be made. Discontent with the provisions of the Versailles Treaty and ineptitudes of the Weimar Government paved the way for the emergence of a fascist leader of Adolf Hitler's type. Hitler's marvellous demagogy, added to the dissensions among the German Left-wing parties, and the period of inflation: all these made easy the path of national socialism. Yet it was a movement built on the sands of slogans rather than on any rock of political philosophy. One slogan it translated into action from the date of the establishment of the Nazi regime, 1933, and onwards: not butter but guns. By rearmament the national socialists solved Germany's bitter unemployment problem, but at the cost till 1939 of the standard of life of the German people and after 1939 of total war for the world and total destruction for Germany. For the rest national socialism swept away the German trade unions, arrested their leaders, seized their funds, and turned them into misbegotten guilds in a Labour Front even more blatantly a party puppet than were Mussolini's corporations.

Nazi Economic Achievements

Germany's achievements in the economic sphere both during the period 1933-39 and during the war cannot yet be fairly appraised. At present, the mistake is frequently made of dismissing everything German as either undesirable or stupid—itself a stupidity (*pace* Lord Vansittart) of no inconsiderable order. No one in his senses would claim for the Western democracies that their present monetary system, whether in Britain or the United States, is socially equitable or even industrially efficient. Not a little of the support which Hitler secured from the German workers came from their belief in the socialistic element in national socialism. In England the

abolition of the gold standard was a sign of the times. Germany's wartime substitution of barter treaties for the long established practices of capitalist trade and the settlement of trade balances by a system of elaborate financial adjustments may long survive Hitlerite Germany.

Again, some of Dr. Schacht's measures as economic dictator were pioneering of which no fair estimate can be expected while the memories of war prevent judicial analysis of the events of the last decade. But little of the credit for Germany's achievements in the economic field goes to the National Socialist Party. Not even prison and concentration camp, the driving into exile of many of the country's greatest minds, can wholly destroy the genius of a nation to whose resource and inventiveness world industry and commerce owe so much.

Russian Communism

The contrast between German national socialism and its improvizations and the elaborate governmental structure of the U.S.S.R. could scarcely be more complete. The latter has a political philosophy behind it; the former had none. The Soviet Constitution of 1936 made a number of significant changes in the earlier Constitution of 1923-24. By the 1936 Constitution the Union is to consist of eleven soviet socialist republics, each of which has the right (at least on paper) of free withdrawal from the Union. The supreme state authority is the Supreme Council of the U.S.S.R.—this replaced the former All-Union Congress of Soviets—whose term of office is four years and whose meetings take place twice yearly. This Supreme Council has two legislative chambers with equal rights, namely: the Council of the Union, elected on the basis of one deputy to three hundred thousand of the population and numbering, therefore, some 550 deputies; and the Council of Nationalities, whose members, some 220 in all, consist of ten each from the Supreme Council of each Union republic, five from each of the autonomous republics, and two from each autonomous province. A conciliation commission arbitrates between the two chambers if they clash. Should no agreement be reached, the Supreme Council would be dissolved and new elections held.

At a joint session the two chambers elect a Presidium consisting of chairman, four vice-chairmen and thirty-one members. This body has extensive administrative powers as well as important executive responsibilities during those periods when the Supreme Council is not sitting: it can declare war and ratify treaties. Moreover, the work of the Council of the People's Commissars, nominees of the Supreme Council, is under its supervision. The Commissars in council act as the state executive and administrative body, corresponding to the British Cabinet. Under chairman (Marshal Stalin, see Fig. 6) and vice-chairmen, its twenty-two members include the Commissars of Defence, Foreign Affairs, Foreign Trade, Railways, Water Transport, Communications and Heavy Industry: these commissariats are wholly to do with the federation of the various republics. Ten other commissariats, including those for Home Affairs, Justice, Health, and Food, act for both the federal union and for the individual republics. The members of the Presidium

are completed by the chairmen respectively of the Soviet Control Commission, of the Art Committee, of the Agricultural Purchasing Committee and of the Committee for Higher Education.

Under the Constitution's Bill of Rights, Soviet citizens are guaranteed the right to work, rest, and maintenance in old age, sickness or incapacity; to be educated, to practise any religion or none, to freedom of speech, press and assembly. Women are equal citizens with men; citizens of all races and all nationalities are equal under the law; political and scientific refugees from other lands are guaranteed asylum in the U.S.S.R.

Fig. 6. *Joseph Stalin (1879–19—) Chairman of the Council of the People's Commissars of the U.S.S.R.*

Provision is made for direct elections and secret ballot: in addition to the Communist Party, trade unions, co-operative societies, youth organizations and cultural groups have the right to put forward candidates. Electoral representation as between town and country is equalized: under the previous Constitution the balances were weighted in favour of urban areas.

The Government hold all land and all natural resources in trust for the people; collective farms are the exception: tenure may be held by perpetual leasehold. The exploitation of natural resources is the responsibility of state trusts. State departments operate air, rail and water transport, posts, telephones and telegraphs. Industry is all but wholly a matter of state enterprise, private enterprise contributing less than one per cent to the country's total production. As to the responsibilities of the citizens to the state, military conscription is enforced in peace and war alike.

The administration of justice is elaborately organized. The Supreme Court of the U.S.S.R. is the apex of a system of federal, republican, provincial and local courts. The Supreme Court supervizes all such judicial bodies; interpretation of laws is left to the Presidium of the Supreme Council. That Council elects the members of the federal courts for a term of five years; its Presidium can, on appeal, upset or reverse the orders and decisions of the federal or republican Councils of Commissars. OGPU (initials standing for the United State Political Department) was abolished in 1935, and its powers transferred to the then newly created Commissariat of Home Affairs.

The Success of Sovietism

The U.S.S.R. is totalitarian in so far as the Communist Party is the only political party recognized in the Soviet Union. A vital difference between this and the totalitar-

ianism of Nazi Germany is that non-party candidates in Russia are freely elected to various public offices. At annual congresses the Communist Party elects its Central Committee which in turn makes selection of the Political Bureau as its executive body. Although this and the Russian Government are not identical, there is no recorded case of a decision on policy made by the former being ignored or reversed by the latter.

While Anglo-Saxon representative democracy cannot logically stomach the totalitarian element in sovietism, only the foolish will deny that not only on paper has the U.S.S.R. a governmental system which challenges comparison with the best, past or present. Before the tremendous years 1941 to 1945 it could have been said that that Government and the Constitution providing for it had not yet met the testing times known to and survived by their counterparts in England and America, and not destroyed beyond redemption in France.

For good or evil, the politically conscious workers of Britain are now convinced that in Russia men of their own class have set up a state machine second to none. The hammer and the sickle are symbols more significant to their daily lives than the crosses of saints. A student of politics notes this, accepts it as a factor making for the strength of the Marxist appeal in this country, but is not necessarily himself convinced that the alternative to capitalism is communism.

The British Labour Party, a home-grown product, has a programme that a Marxist intellectual can pull to pieces as inconsistent and illogical, an affair of patches and makeshifts, of compromise and contradiction. In so far as the inconsistent and illogical British people appear to delight in patches and makeshifts and to thrive politically on compromise, whether or not this is contradictory of political theory or previous political practice, this would-be damnation may itself be regarded as praise.

The British Parliament

There can be no more striking foil to the Soviet governmental machine than the British Parliament. As has been seen—and the description applies to most of the world's newer parliaments—the Soviet political system provides a beautifully tidy instrument of government, each part dovetailed into the next, and the whole a logically functioning, effectively governing unit of legislature. Not so the British Parliament. Like Topsy it has "just growed." Whereas many parliaments owe their origins to a successful revolution, the British Parliament, with the exception of the civil wars (1642-45), owes its own to a process of evolution, a growth by trial and error, that has known many failures and turned not a few of them into tried successes.

The British Parliament consists of the Crown, the Lords Spiritual and Temporal, and the Commons; its two houses are the House of Lords and the House of Commons. The source of its authority is still technically the Crown; for by the sovereign it is summoned, prorogued, and dissolved, and the writs for the election of its members issued. It is not by the Prime Minister's but by the King's speech at the State Opening of Parliament

(see Fig. 7) that the Government of the day states the reason for Parliament's summoning and outlines the legislation to be introduced. Such legislation, although passed by both Houses, requires the Royal Assent before it becomes law. Technically, the sovereign has still the power to veto any such legislation, although constitutionally the sovereign acts only on the advice of ministers. Legislation is therefore enacted by the sovereign by and with the advice and consent of the House of Parliament. Were the sovereign's power of veto exercised, as has not been the case since the early eighteenth century, loyalty to the monarchy, now so great, would be impaired—possibly to an irretrievable extent.

The House of Lords

The House of Lords (see Fig. 8) is more than a museum piece. Membership of the Upper House is by: (1) hereditary right; (2) creation by the Crown, or (3) appointment to an English bishopric: twenty-six "Lords Spiritual" have seats in the Upper House; while twenty-eight Irish peers are elected for life, and sixteen Scottish peers for the duration of Parliament. The House of Lords was by the Parliament Act of 1911 deprived of a number of its powers: it can no longer initiate legislation that would involve additional taxation; it cannot throw out a Money Bill once that has been passed by the House of Commons; while any Bill, apart from a Money Bill, passed in three successive sessions by the Commons, becomes law after two years, despite rejection by the Lords.

Even so, the House of Lords has very real powers. It is the highest court of law in the land; among its personnel are to be found some of the best brains in the country, experienced in commerce, industry and the professions and, in recent years since the rise of the Labour Party and the elevation of a number of its members to the peerage, in not a few instances experienced in the way of life of the workers and aware of their needs.

It is no difficult matter to set out a case against the House of Lords. A legislative body having over seven hundred members of whom those who attend its debates with any regularity are some two score is both clumsy and inefficient. Its archaic usages and conventions, the very titles which qualify for its membership—a jug with a handle is functional, a man with a handle too often farcical—above all the hereditary principle: all these are far from being in accord with either the letter or the spirit of representative democracy. Even so the quality of the Lords' debates is not seldom high; the individual contributions of the faithful few who take their duties seriously are often of considerable value; the permanency of tenure has its advantages as well as its disadvantages. Because, however, it is the House of Commons that represents the people by whom it is elected and that should, and often does, carry out the people's will, Labour's conference decisions to abolish the House of Lords in its present form undoubtedly represent the will of more than the politically conscious workers as such.

Life of Parliament

In peace-time the full term of any one Parliament is limited to five years, although the defeat of the

Fig. 7. *The pageantry of government. Britain's Sovereign and his Consort leaving the House of Lords in their historic coach after the State Opening of Parliament. Note the "Beefeaters" (Yeoman of the Guard) marching behind the state coach in their picturesque and traditional costumes.*

Government on any major issue normally involves an appeal to the country at a general election; such a mandate, too, must be sought at the end of any quinquennial term. Parliament is legally obliged to meet in session once in three years; it does in fact hold its sessions annually in peace and war alike. By special legislation Parliament during both the world wars extended its own life, such extensions covering a year at a time. Thus the Parliament which was elected in November, 1935, remained in being until May, 1945.

The Party System

The leader of the party acquiring a majority at a general election is invited by the sovereign to form a government and cabinet. In this cabinet government policy is debated and decided; each cabinet minister is bound to support that policy or to resign if he can no longer give it that support. Conversely, the cabinet is responsible for any and every official action its individual members take. Such collective responsibility is fundamental in British cabinet procedure.

The British system of party politics is subjected to constant criticism, much of it facile. It rarely occurs to the critics that were party organizations to go, cabinet government would need to go also; for unless a cabinet can depend on the support of a majority in the House of Commons, its days are numbered; while some kind of grouping among men holding views of the same kind is desirable as well as inevitable. The case against the more tyrannical side of party organization is on firmer ground. Party whips can be a poor substitute for an individual member's conscience. Yet any member persisting in defying his whip's instructions by voting against his party in parliamentary divisions is dealt with by the withdrawal of the party whip, the loss of official party (and financial) support at the next election, and in consequence probable loss of his seat, whatever the party's fortunes generally. On the other hand, the whip's work in keeping the party leadership in touch with the feeling of the rank and file is good in itself and democratically sound. The whips of the party in office are paid for their work, which includes the arrangement of the business of the House.

The Chief Whip's contacts with the Prime Minister are close and constant that the Premier may receive frequent reports of the consensus of opinion among government supporters on this or that item of cabinet policy. The most important function of the whips is, however, to ensure proper attendance in debates, and a full muster of their party's supporters in important divisions.

Parliamentary Procedure

Every member, after election, takes the oath. If the office is vacant, a Speaker is elected to preside over the House and to give rulings during debate and with regard to procedure, much as does the chairman of an ordinary public meeting. The Speaker's powers are considerable. No member can address the House without his sanction, although the business of "catching the Speaker's eye" is a less spontaneous affair than the phrase suggests. In so far as it is the Speaker's right to accept or reject a motion to that end, he can cut short a debate or permit it to

Fig. 8. *The House of Lords, showing the thrones occupied by the King and Queen at the State Opening of Parliament.*

continue by his decision as to when a division shall take place. He can call a member to order, order him to leave the House till the sitting be over, or "name" him that the House itself may decide on the period of his suspension. To preserve his impartiality he forgoes his own right to vote in a division and is thus unable to act directly for his constituents.

The difficulty in the British as in any other democratic legislature is to reconcile the need to give freedom of expression to every legislator, which necessarily may involve long debates, and yet prevent those debates from becoming so lengthy that no decisions are reached and no business is transacted. To secure the closure, a member with the Speaker's consent moves that "the motion be now put"; this, if carried, means that a division is taken on the point under debate. The Government has a further recourse—to the guillotine. By this device time given to a particular clause or section of a Bill is definitely limited; when that limit is reached, the debate ends and one or more divisions are taken on the outstanding clauses. The guillotine is a convenience to a Government, an abomination to an Opposition, and unpopular in the House generally which nevertheless accepts it as a necessary evil. Along with the guillotine goes the kangaroo method of selecting amendments for discussion, by which a whole series of amendments can be skipped at the discretion of the Speaker or his deputy.

Parliament's primary function is to pass Bills: these may be either Private Bills (relating to private interests, as for example a Bill enabling a transport, gas, electricity or water undertaking to extend its scope or its powers), or Public Bills, relating to the general interest

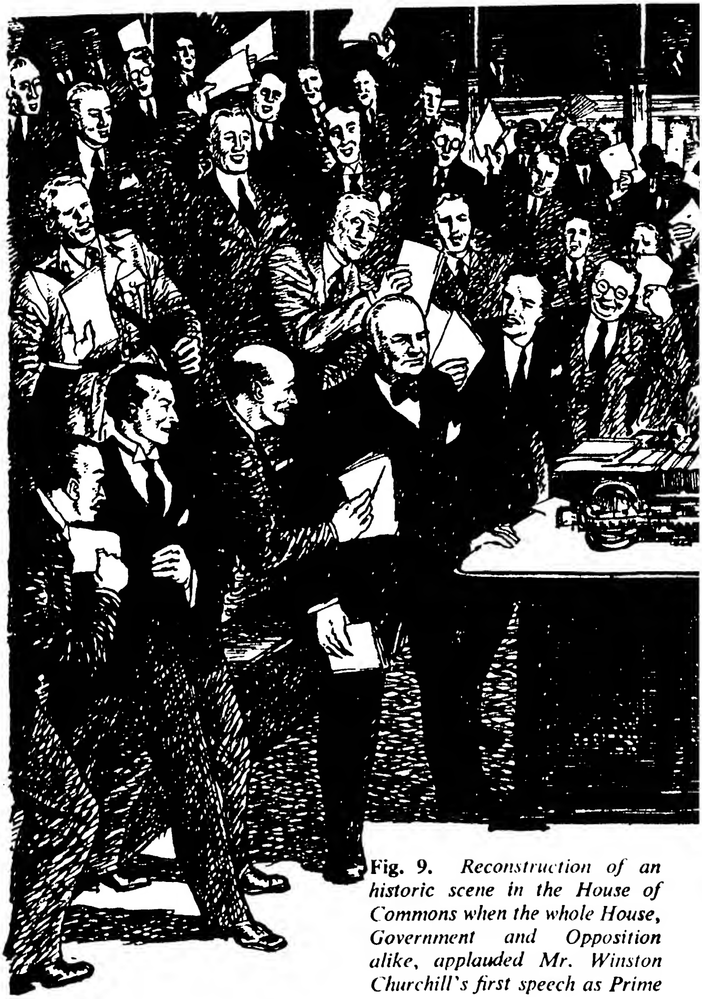


Fig. 9. *Reconstruction of an historic scene in the House of Commons when the whole House, Government and Opposition alike, applauded Mr. Winston Churchill's first speech as Prime*

and affecting the community as a whole. It is a modern paradox that while in Britain for a century past the democratic state has acquired ever increasing rights of control over the interests of individuals, the country's elected democratic representatives have come to have, as individuals, a steadily diminishing chance of promoting legislation. Admittedly, a Public Bill can be introduced by a private

Minister. The Speaker (centre), as befits his impartial office, remains seated. Below him are the Clerk of the House with his two assistants. The mace, a burnished brass symbol of the House's authority, rests on the Clerk's table while the Speaker is seated in the chair.

member; unless the Government backs it, it rarely becomes law, whereas everything is done to facilitate the passing of a Government-promoted Public Bill.

When the formal First Reading by the Clerk at the table of the Title of a Bill is over, the Bill receives a Second Reading (usually at a much later date) when the principle of the Bill is debated on the floor of the House. The House

consenting, it then goes to Committee, that is either one of the half-dozen standing committees or, in the instance of the Budget or other Money Bill, a committee of the whole House, to which on the Commons' direction other Bills also can be sent. When the whole House sits as a committee, the Speaker does not preside. It is the duty of each committee to give each Bill sent to it detailed examination, to study suggested amendments, accepting or rejecting them, and to report through its Chairman to the Speaker the content of the Bill if and as amended. The Report Stage is entered upon when the Commons consider the Bill as reported to them: during this stage other amendments may be argued for and against. The Third Reading reverts to a discussion of the Bill's fundamentals; during this no more than verbal alterations can be made. Through its Third Reading, the Bill goes to the Lords.

Private Bills

Procedure for Private Bills follows that for Public Bills with relatively minor variations designed for the most part to safeguard interests differing from those of the undertaking promoting the Bill in question. Parliament's standing orders provide that by public notice and advertisement the proposals made in the Bill shall be made known, that objections to them may be raised and considered. Following the First and Second Readings, a committee, usually of four, examines the Bill's clauses judicially and in detail, and amends them if need be; hears counsel and witnesses, inspects the plans submitted, and finally reports the Bill to the Commons where it passes through the same final stages as a Public Bill before reaching the Lords. Private Bills can be introduced in the House of Lords (and often are, that the time of the business-burdened Commons may not be further encroached upon); like Public Bills they do not reach the Statute Book until they have received the formal Royal Assent given through the Lords Commissioners in the House of Lords.

Private Members' Powers

Small opportunity as the private member has to promote legislation, only his own temperament can render him a mere rubber stamp for his party's use. At question time he can ventilate the grievance of an individual constituent or of a body of his constituents; he can question the minister in charge of a department as to any alleged irregularity or slackness in that department. In debate he can bring to bear any specialized knowledge of his own to reveal flaws in, or suggest improvements to, the Bill under discussion. In committee he can be constructive or destructive in his criticism and both may be of value to the state. In the smoking and dining rooms of the House he can, if his personality permit, make himself sufficiently liked and respected even by his political opponents for his words from the floor of the House to command attention. In his constituency he can do not a little good work which is outside party and for the general benefit of his constituents. For it must be remembered that a candidate, once elected, represents his constituency and not merely the electors who, holding his party's views, have voted for him. By being accessible

to constituents when they visit the House he can help to give the ordinary citizen a further realization of the nature of the work Parliament does session by session.

Powers of Ministers and Departments

So much for the private member. What of the cabinet minister; what of the great state departments? C. Delisle Burns has well said: "The daily activities of administrative or official bodies are more important than occasional legislation or the acts of a judicature; for government is now a continuous process, not an occasional intervention or corrective." The less thoughtful, less knowledgeable cynic is wont to say that Governments come and go, the Civil Service remains, and is the country's permanent ruler. The measure of truth in this lies in the fact that in Britain the state is now manager of a score of vast businesses and of a host of employees. Moreover, whereas in the U.S.S.R. the state has all but abolished private enterprise, in Britain the state's activities need to be prosecuted with a constant respect—often all too great a respect, some assert—for the activities of private enterprise.

Any citizen has the right to induce any member of Parliament to ask questions in the House about the work of any state department. In effect these departments have not only the annual check by government auditors but a continuous check by citizens through their elected representatives. As a result of this, the minister in charge of a department has, with the civil servants whose chief he is, not only to see that the department's work is done, but to be in a position to give an account or a defence of it on any day while Parliament sits. Thus, although the charges of bureaucracy levelled against state enterprise are not altogether without foundation, the trend in state enterprise is to vest control not in Civil Service bureaucrats but in technically competent and semi-independent Boards. Recruitment of the Civil Service generally by open competition is some safeguard, too, against an excessive bureaucratization.

A health-insurance card or an old-age-pensioner's book, an unemployment-insurance card, a "pay-as-you-earn" income-tax statement in a pay packet: these are symbols of three of the great state departments: Health, Labour and the Treasury, with the newly formed Ministry of National Insurance also implicitly indicated. The average citizen is acquainted with little more than the symbol: of the amount and complexity of the work involved administratively he has little knowledge. The postman's double knock, the schoolchild's report, the sight of a service or police uniform: these are evidence of the work of the Postmaster-General, the Ministry of Education, the Lords of the Admiralty, the Secretary of State for War or Air, the Home Secretary. Who are these functionaries? What is their work, and what is the work of others of their ministerial colleagues?

Finance

When a party leader successful at a general election forms his government, he becomes not only Prime Minister but normally also First Lord of the Treasury, the Lord High Treasurer of England, to give him the picturesque title of the early holders of his office, an office

instituted in 1612. The First Lord, together with the Junior Lords of the Treasury, is responsible mainly for the political side; the Chancellor of the Exchequer is in charge of the financial side. The Chancellor's task is to receive the estimates of the state's spending departments, to approve of them or to whittle them down if he considers them excessive or disproportionate to the public funds available, and having thus arrived at the total figure of national spending to arrange that the state's collecting departments shall raise sufficient revenue to meet the country's expenditure for the year. These two series of estimates are detailed in papers which, collectively, form a budget in the ordinary sense of the term and, when laid before Parliament by the Chancellor of the Exchequer, are known as the National Budget, the Budget for short. This, embodied in the Money Resolutions and presented in the Finance Bill, is debated by the House, rejected or accepted or amended, and eventually becomes the Finance Act of that year.

During 1939-45, total war saw the British Government use financial policy in a fashion and to an end that would have appalled *laisser-faire* Liberalism of last century. The subsidizing of necessities, the control of prices, and the many ways in which private expenditure was severely restricted, did much to bring it about that the national resources were used only to serve the national purpose, the successful waging of the war. This use of financial policy did not end with the war or its immediate aftermath. Incidentally, it may be mentioned that the greatest and most benevolent of the frauds a government has practised on a people has been the various Savings Weeks—"Wings for Victory," "War Weapons," and the rest. Not one of these directly contributed a single additional weapon to the national armament; they served their purpose no less adequately. In fact, the National Savings Movement gathered about £10,000 million out of the consumers' hands and made it available for government expenditure.

It is the mark of a good Chancellor of the Exchequer when both national expenditure and national revenue approximate at the end of the financial year to the forecasts made in the Budget. British peacetime Budgets have been remarkably successful, when judged by this criterion. Critics, however, assert that this success is dearly bought: that to obtain it the Treasury tyrannizes over other departments by its power to grant or withhold finance, and therefore moulds if not dictates policy. British Budgets as mere book-keeping on a colossal scale are the admiration of the finance ministries of the world.

The organization of the Treasury is complex. Sufficient here to state that there are three main divisions: the Policy Division, where policy is studied from the finance angle; Establishments, responsible for Civil Service staffing; Supply, concerned with the estimates. The Treasury has mechanism, too, for the minute scrutiny of the public finances. It is responsible for the collection of the public revenues and management of the Inland Revenue staff.

The Fighting Services

The Admiralty, the War Office, and the Air Ministry are the departments governing the fighting forces. The Air Ministry, formed

in 1918 and controlling the then Royal Flying Corps and the Royal Naval Air Service, is the junior, and the Admiralty administering the Royal Navy and the Royal Marines is the senior (the Board of Admiralty itself is over one hundred and twenty years old and successor to the centuries-old Navy Board). The Army Council, the War Office's supreme administrative body, dating from 1904 only, with its membership of eight, ensures that the Army shall be responsible to Parliament; in the Air Ministry the Air Council performs the same function for the Air Force.

In addition to the responsibility of the fighting forces there is the Prime Minister's responsibility in his capacity as Minister of Defence, and the co-ordinating machinery represented by the Committee of Imperial Defence.

Home Affairs and Labour

In peace-time the activities of the service departments are remote from the private citizen; other departments of state directly influence his daily life. The Home Secretary is the normal intermediary between the Sovereign and his subjects. His department is also concerned with, among many other things: the maintenance of law and order, and many aspects of the administration of justice; police forces; prisons and other places of civilian detention; the liquor trade; suppression of the white slave traffic; supervision of such widely separated activities as vivisection and bird snaring; registration of electors; conduct of general and local elections. But since 1939 the inspection of factories and workshops, industrial disputes, administration of employment exchanges and such matters as the direction of young men into the fighting forces have been dealt with by the Ministry of Labour.

Scottish and Indian Affairs

The jurisdiction of the Home Office does not extend to Scotland, which has its own Scottish Office and Secretary of State. This, and the India Office, which forms the link between the Government of the United Kingdom in London and the Government of India in New Delhi, are two typical British experiments in attempting to meet the varying needs of two parts of that strange conglomeration of communities, the British Commonwealth of Nations. The history, past and present, of both these, provides evidence of the spontaneous growth of British governmental bodies, and of the rejection by the political genius of the nation of any cut-and-dried formula for the framing of its democratic institutions. A Secretaryship of State for Burma exists, and is a separate office, although normally held by the Secretary of State for India.

Education and Trade

The Board of Education became a Ministry in 1944. The Education Act of that year, which achieved a minor revolution in English schools, and the advent of the spartan post-war years with their demand that all national skills and talents shall be trained and used to the full, require the Ministry of Education, always the ministry of youth and hope, to become more than ever the ministry for the ripening and fulfilment of youth's potentialities.

Like the old woman of the nursery-rhyme shoe, the Board of Trade, formed in 1786, has a host

of maternal responsibilities, including both public and private bodies. The British capitalist system creates a never-ending series of problems arising from the need to reconcile public and private interests, with which the Board of Trade must deal. Its President is rarely a popular minister, and the measure of his unpopularity is not seldom a criterion of his faithfulness as a watchdog for the public interest as against the smash and grab activities of irresponsible commercialists.

Foreign and Empire Affairs

The Foreign Office, least democratic of the state departments, illustrates the aristocratic elements in the British political and social hotchpotch at both their best and their worst. In 1782 it inherited the duties of the oddly named Secretary for the Northern Department of Europe. Its function is to handle communications between Great Britain and foreign governments, and also the heavy correspondence with diplomatic and consular agents; and to obtain through its ambassadors, legates, and representatives generally, the information upon which the cabinet can base its foreign policy. Too much social top drawer and over many old school ties have too often made the British diplomat, impressive figure though he has frequently been, an irritating and inexplicable person to the more democratically minded peoples of the world, and an incarnation of class privilege and class distinction to the more politically conscious elements among the British workers.

However, the Labour Party has already produced two great Foreign Secretaries, Arthur Henderson and Ernest Bevin, both of whom came from working-class homes. In addition, entry into the diplomatic service is now by open competition.

Government transactions to do with the Colonies were, until 1801, the affair of the Home Secretary. From 1801 to 1854 they were among the duties of the Secretary for War; in the latter year a separate Secretary of State for the Colonies was created. In 1925 all business connected with the self-governing Dominions, including Eire, and also that to do with Southern Rhodesia, Basutoland, the Bechuanaland Protectorate and Swaziland, was transferred to the newly created Dominions Office, which is responsible also for the affairs of the Imperial Conference.

Health and Local Government

The Ministry of Health, born in 1919 of the Local Government Board, is the medico among the great departments. It seeks to conserve and lengthen life and to improve public health: expectant mothers, children and young persons, lunatics and mental deficients are among its many protégés to whom especial attention is given. It is also responsible for housing and is concerned, broadly speaking, with the structure and finance of local government.

Although the spotlight of public interest tends to be focused on national politics as opposed to local, the relatively recent policy by which the central government makes use of local authorities for the administration of Acts to do with housing, health and similar public concerns has given local government steadily increasing importance. The elector, as such, uses his parliamentary vote normally only once in five years, and the political worker is active

only intensively at general election times with, if he is zealous, party work in the constituency taking up a modicum of his leisure. Nevertheless, a citizen can, and often does, devote half or more of his spare time to public affairs as a local councillor, acting on various committees or other public organizations. What then of local government in Britain?

The subject is an immense one. Books dealing with it fill the libraries, and constitute a library in themselves. The greatest political classics of our days, those of Sidney and Beatrice Webb, deal with it comprehensively and with genius. So unlikely a genius as George Bernard Shaw was content to perform long spells of patient drudgery as a Vestryman of St. Pancras. No more than a mere shadow of an indication of the importance and scope of British local government can, unfortunately, be given here.

History of Local Government

Local government is of necessity subordinate to national government which interprets as well as institutes the statutes affecting local authorities. Elizabeth's reign saw the first serious attempts made to organize local affairs: these in the main were entrusted to the Justices of the Peace. It was only in the nineteenth century, when the impact of the Industrial Revolution was making itself felt upon many sides of the national life, that a real effort was made to grapple with local government problems and to set up machinery capable of dealing with them. Some landmarks include: the Poor Law Amendment Act, 1834, which attempted to systematize poor relief by the appointment of a central authority to administer it; 1835 saw the Municipal Corporations Act which regulated voters' rights and restricted the old privileges of the borough freemen of 178 municipalities; the Public Health Act, 1848, which made sanitation the responsibility of the local authority, and the similar but more comprehensive Act of 1875 which extended both the powers and the duties of local government bodies; the Reform Act, 1867, which enfranchised a large body of industrial workers; while the setting up of the Local Government Board was a modest anticipation of the Ministry of Health which in 1919 took over the duties of the Local Government Board and was equipped with greater powers and wider authority. The Reform Act, 1884, enfranchising agricultural labourers, was followed by the Local Government Act of 1888, something of a minor Magna Carta in that for the first time the counties acquired county councils, formed by democratically elected representatives in place of those nominees, the Justices of the Peace, whose natural outlook was varyingly feudal rather than democratic.

Equalizing Rates

The later Local Government Acts of 1894, 1929 and 1933 indicate how new social needs have arisen and how attempts have been made to meet these by the provision of new social services. Moreover, each new Act has had to be framed with some reference to the one need that dominates the rest: that the burden of local taxation, that is rates, shall be as far as possible equalized as between poor authority and rich, and between town and country. How crucial is this last question can be gleaned from two facts:

in the years immediately before the Second World War rates varied from 2s. to 30s. in the £, according to the area in which they were collected; again, Westminster with its population of one hundred and thirty thousand had a rateable value of £10½ million, while Poplar, with one hundred and fifty-five thousand inhabitants had a rateable value of just over three-quarters of a million and a rate (such as in 1936-1937) of 18s. in the £ as against Westminster's 9s. 10d.

Local Government Finance and Structure

Definitions of "rate" and "rateable value" become necessary. A rate is a local tax paid by the occupier of immovable property (that is houses, business places, factories, etc.) based on the assessed annual value of that property, that value being the amount of the rent for which it is assumed it would be let yearly. The local authority makes the assessment; the total of such assessments of all properties in its area is known as the authority's rateable value. Estimates having been made of local expenditure for the coming year, total rateable value divided by total expenditure fixes the rate per £ of assessed value which the occupier has to pay.

It needs to be stressed that the rate is the one tax a local authority can levy, all taxation of income, commodities (including such commodities as entertainment) and rights (such as that of driving a car or possessing a gun) being the prerogatives of the state. At the same time the rate is not the local authority's sole source of revenue. Government grants made from state revenue provide one-third of the cost of local services. Of the total expenditure, including that on local social services, approximately one-fifth is contributed by the state. Of the remaining four-fifths, rents and tolls, dues and various kinds of fees provide rather less than, and the rates rather more than, half.

The citizen who, as a councillor, serves on a borough, an urban or a rural district council, and particularly if he be a member of the finance committee, finds how dovetailed local and national finances are, and how complicated the financial adjustments that need to be made as between local and central governments on matters such as education, housing and health services where the functions of each overlap those of the other.

There is a kind of pyramidal structure about local government. Administration is shared by county councils, borough councils for both county and non-county boroughs (any newly created county borough needs to have fifty thousand population as a minimum), urban district and rural district councils, and parish councils. County councils and county borough councils with equal powers have authority over the lesser councils: thus the county rate is a priority local government charge on the revenues of an urban or rural district or parish council; while such authorities have no power to impose a similar levy on the county council.

Unplanned Development

As with national so with local government, Britain has lost much as well as gained something by the fact that she has had no revolution such as the French or the Russian with which to wipe the political slate clean; that in less than two hundred years Britain has made the

change over from her agricultural preoccupations to the highly organized industrialism of today, and adapted her political and social need to the event and after it. Britain has lost something by the fact that her genius is for improvisation rather than for long-term planning; that planning has been, and to some extent remains, so far outside her normal approach to a need or a situation that even now to a big and influential section of her people planning is suspect. Her planners are too often self-conscious, aware of hostility expressed and unexpressed, and handicapped by a national heritage and tradition. In this tradition feudalism is valued for its picturesqueness and wrongs are defended as rights because they have the sanction of the centuries. Nowhere can this be more plainly seen than in the facts of London local government and the problems London's governors have to face. The pattern of London and its government is the pattern of British local communities and their rule.

The City of London

London! A marvel and a mess; not one town but many; a clearing house for the world in trade and finance and the abiding place of eight million people: such a community might well provide a local government nightmare for anyone but a mad Britisher. At its heart is the square mile of the City, where half a million work by day and some ten thousand only sleep by night (the war modified these figures, but only temporarily): this focal London is for the most part ruled by the City Corporation. The City's freemen compose this corporation and are the City's only local electors. The Corporation has not one but three councils. The Court of Common Council, presided over by the Lord Mayor, has 206 Common Councillors elected annually; its twenty-five Aldermen, elected for life, form a second governing body, the Court of Aldermen, whose rights include control of the City's historic livery Companies. Finally, the Court of Common Hall, with its membership restricted to the Liverymen of those Companies, elects the Sheriffs, the City Chamberlain, Remembrancer, and lesser officers, and nominates the last two candidates for the Lord Mayoralty.

The County of London

Radiating from the City north and south of the Thames is the Administrative County of London, which since the Local Government Act of 1888 has covered 117 square miles with a population approaching four and a half millions in 1939. Thirty separate public bodies—twenty-eight metropolitan boroughs, the City Corporation and the London County Council, of which the last is incomparably the most important—are charged with the local government of this wide area. Greater London with its all but seven hundred square miles and eight million population is the area served by the Metropolitan Police, most of which ground has the Metropolitan Water Board as its water suppliers. Widest of all is the London Passenger Transport Board's area—1,840 square miles.

The L.C.C.

County Hall, the London County Council's parliament house, houses a legislature whose revenues and expenditures are greater than those of many of the world's smaller states. The Council's personnel

consists of chairman, twenty aldermen, and 124 councillors (see Fig. 10). The councillors, elected directly by the ratepayers for a three-year term, man the various committees through which the Council exercises its powers, subject to strict rules and the reservation to the Council itself of decision in matters of principle. The most important of these, the Finance Committee, a body with wide statutory powers, estimated for a total expenditure in 1945-1946 of £45½ million, of which £18 million was to be raised from rates. Its accounts showed a net debt of over £80 million, including £52¾ million in respect of housing. These huge figures indicate that the London County Council is the principal revenue-raising body for all the Administrative County's local authorities.

The Second World War added the organization of civil defence to the General Purposes Committee's duties; the Education Committee is responsible for an expenditure of some £14 million (the 1944 Education Act will ultimately vastly increase this figure), and the maintenance of some 1,100 elementary and 240 secondary and technical schools, evening institutes and training colleges, attending which are more than seven hundred thousand pupils and students. The Hospitals and Medical Services' Committee maintains seventy-five hospitals, accommodating 36,400 patients and requiring nearly £7 million a year for maintenance. The Housing and Public Health Committee administers the various Housing Acts in so far as they concern the London County Council area. Before the war intervened this Committee was committed to an expenditure of £50 million for slum clearance and rehabilitation to be spread over the years 1934-1944; and it is responsible for the metropolitan main-drainage system covering 179 square miles, and served by 400 miles of sewers, twelve pumping stations and five sludge vessels.

This is but the beginning of the catalogue of the London County Council's committees. The Londoner proud of his city, the Briton proud of his country's capital, will find even a casual study of the activities of the London County Council full of amazement, full of fascination. The provision of a public wash-house in a suburban back street may not be the most majestic expression of democracy in action: it means more to a free people however, so far as general principle is in question, than the most munificent gift of the proudest of public buildings by the most benevolent of despots.

Local Councils and Services

It was the Local Government Act of 1888 which created the London County Council; while the Local Government Act of 1899 transformed the various metropolitan vestries into twenty-eight Metropolitan Boroughs, of which Westminster, a year later, became a city. The twenty-seven boroughs have each a council with a mayor and, according to size, thirty to sixty councillors elected by direct local vote, and five to ten aldermen (their number being one-sixth that of the councillors) elected by the councillors themselves. The councils of towns which have no borough status, of urban districts, rural districts and of parishes follow the same British pattern: they give the civic-minded Briton, whether man

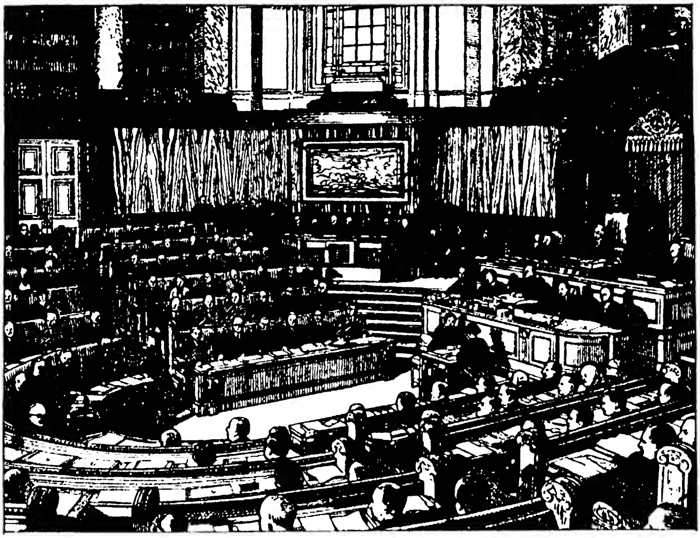


Fig. 10. *The London County Council in session at County Hall. This authority controls greater revenues and influences the lives of more people than many of the world's sovereign states.*

or woman, the opportunity to play his part as representative or elector in the quiet drama of democracy at work.

On the back of any Rate Demand Note will be found set out a statement of how the rate is allocated against the services supplied by the urban or rural council on the one hand and the county council on the other. The district council is responsible for housing (in most instances), water, sewage disposal, scavenging and (in war-time) air raid precautions; the county council for elementary and higher education, public assistance, police, highways and bridges, and public health. In the body of this statement is a reference to "government grants under the Local Government Act, 1929," and the Demand often concludes with a note of services, and the rate allocations for them, administered by "Precepting Authorities" other than the county council. On the face of the Demand is a reference also to the Rating and Valuation Act, 1925.

The two Acts quoted are the keystones of modern local administration, that of 1925 concerned with the local machinery for revenue-raising; that of 1929 regulating on new lines the financial relationship of state and local authority. Under the 1925 Act the Boards of Guardians lost their function of fixing and collecting rates, while the county borough councils undertook this dual task in their own areas, and municipal borough councils, urban district councils and rural district councils were charged with the collection of their own rates and of the county rates for county services

such as those indicated above: in technical language the county *precepts* the urban district councils and the rural district councils.

Modifying the Rating System

The world slump of 1929 onwards had its direct incidence on local rates. The item "Public Assistance" became so heavy in some of the worst-hit urban areas that even a sky-high rate failed to raise the revenue required. Moreover mines, railways, docks, canals, factories and workshops tended to be in just those poor working-class areas where unemployment and its cost were highest. It followed that businesses engaged in export and faced with ever-growing competition for the dwindling trade markets of the world had the additional hardship of huge local taxation burdens; equally, British agriculture, struggling to maintain itself against the competition of cheap imported food, suffered from a similar burden. The 1929 Act, therefore, wholly de-rated agricultural land and buildings, and reduced by three-quarters rates on buildings used for purposes of production (as opposed to distribution), and on railways, docks and canals, with the stipulation that the latter should take advantage of the 75 per cent rate relief to reduce their own charges to commercial undertakings.

Such drastic de-rating meant a serious reduction in the income of local authorities, estimated throughout the country at some £24 million. A further reduction of about £16 million was made by the abolition of state grants in aid for all services

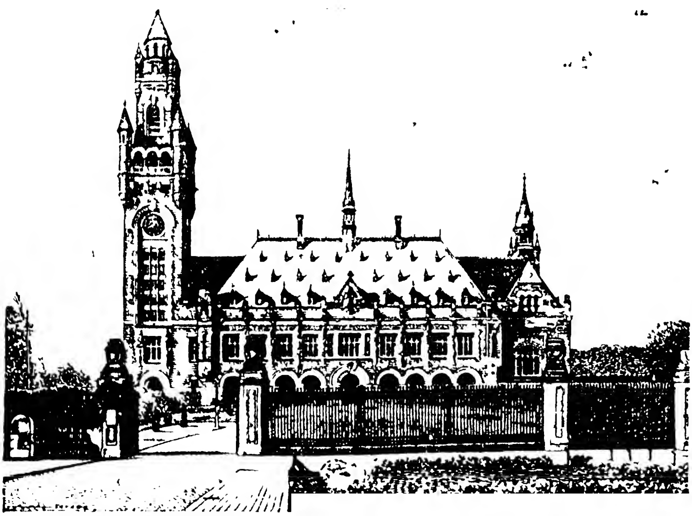


Fig. 11. *The Palace of Peace at The Hague, seat of the International Court of Arbitration established in 1899 by the first Hague Conference, and of the Permanent Court of International Justice set up by the League of Nations.*

other than education, housing, police and, to a limited extent, roads. To recoup local government bodies for their total loss of £40 million, Exchequer grants amounting to that sum were made, to be allocated by the local authorities themselves.

The end of the Second World War on August 14, 1945, saw British local government faced both by the most tremendous crisis in its history and by its most magnificent opportunity. The solution, or rather series of solutions, can come only nationally. Enemy action has destroyed hundreds of thousands of houses and depreciated the worth of millions more upon the net annual value of which local taxation is based. Even before 1939 the provision of houses was much below social requirements; slums shortened and impoverished lives; poor quality building robbed the people of much human happiness. It is impossible, then, that rates as hitherto levied can remain the basic source of local government revenue. Various alternatives have been proposed, including that of a local tax on land values or some form of local income tax. This is not the place for an analysis of such proposals; still less is it the place for prophecy. Enough that the genius for self-government, local as well as national, of the British people has now both the need and the opportunity to make full use of the devoted research of those great authorities on local government, Sidney and Beatrice Webb.

International Government

No outline of politics can be complete without some brief account of men's attempts at international government. The Roman Empire, the Holy Roman Empire, and the British Empire, the Hague Conference and the Hague Palace of Peace (see Fig. 11); the first League of Nations with Geneva as a world political metropolis and a focal point of mankind's hopes of world peace; the San Francisco Conference and the Charter of the United Nations to which more than fifty Governments have given their adherence: all these represent notable examples of humanity's groping endeavours to realize in practical political form something of the centuries-old ideal of world brotherhood and universal peace. The *pax Romana*, always uneasy at the perimeter of Rome's wide-flung empire and rarely untroubled at the centre, did endure for four hundred years.

The British Commonwealth

The Constitution of the British Empire was radically altered after the passing of the Statute of Westminster in 1931. The Empire's slow and typically British evolution had at last begun to prove that empire and democracy were not mutually excluding terms. The British Commonwealth of Nations, which is the more accurate description of the British Empire dating from 1931, is a unique experiment which politicians the world over can—many do—study with profit. What then was the Statute of Westminster, that portentous Act for which history has no precedent?

Becoming law on December 11, 1931, it formally ratified certain declarations and resolutions of the Imperial Conferences of 1926 and 1930, in which Great Britain and Northern Ireland, the Dominions of Canada, Australia, New Zealand, South Africa, the Irish Free State and Newfoundland took part. The

1926 Conference defined these Dominions as "autonomous communities within the British Empire, equal in status, in no way subordinate one to another in any aspect of their domestic or external affairs, though united by a common allegiance to the Crown, and freely associated as members of the British Commonwealth of Nations." The definition was further elaborated: "Every self-governing member of the Empire is master of its destiny. In fact if not always in form, it is subject to no more compulsion whatever."

By the same Conference's decision the Dominions' Governors-General became representatives of the British Crown and not of the British Government; while it was laid down that "it is the right of the Government of the Dominion to advise the Crown in all matters relating to its affairs." The Dominions' right within certain limits to make treaties was recognized; of the six Dominions all but Newfoundland (which in 1933 temporarily lost its Dominion status, restoration of which is now being pressed for in recognition of Newfoundland's devotion to the British Commonwealth's cause in the Second World War) had independent seats in the first League of Nations.

The Imperial Conference drafted the Statute of Westminster which swept away the last limitations on Dominion freedom by declaring that no Act of the British Parliament shall extend to a Dominion unless that Dominion itself has requested and consented to its enactment; it repealed the Colonial Laws Validity Act, 1865, which pronounced that any legislation by a Dominion parliament was void if it conflicted with any Act passed in the mother country; the Statute further declared that any Dominion parliament has full powers to make laws with extra-territorial effect—in other words, to control, like a sovereign state, acts of its nationals beyond Dominion territory.

The Tested Commonwealth

In 1931 the cynical, while giving high marks to the Statute of Westminster as a document which on paper carried imperial devolution to an unparalleled length, questioned whether an imperial emergency like a second world war would not inevitably see that document treated as "a mere scrap of paper," to quote Chancellor Bethmann-Hollweg's phrase of 1914 in relation to the treaty guaranteeing Belgium's neutrality. Within eight years the Second World War had begun, and despite nearly six years of desperate strain such as no empire had previously undergone and survived, the Statute of Westminster was honoured.

The action of the Irish Free State in exercising her right under the Statute to remain neutral put British good faith to one of the hardest of tests. As Mr. de Valera freely admitted in May, 1945, that test was passed with honours. To the student of international government the fact that Eire was not coerced despite Britain's desperate need to use the southern Irish ports will be an event of far-reaching importance in the years that lie ahead.

Wars have been won and lost many times before in the world's history—the resurgence of Germany between 1918 and 1939 shows that defeat can be as temporary as victory may be ephemeral. What

Fig. 12. *President Woodrow Wilson (left) driving through Paris with Raymond Poincaré, then President of France, in 1919. Wilson gave to the world a new hope of peace with his famous Fourteen Points, and with the League of Nations of which he was one of the principal architects.*

is new in world history is loyalty to law by the leading member of a commonwealth of nations which, taking the short view, it would appear had very much to gain by the breaking of the law.

The League of Nations

The vindication of the Statute of Westminster, perhaps the greatest of all the British Empire's moral triumphs, contrasts notably with the failure of the League of Nations. Perhaps never has a human institution been the focus of more of mankind's hopes or the cause of such bitter human disappointment as was the tragic League. The idea of the League belonged to no one man or nation. But for the realization of that idea, as embodied in the Covenant of the League of Nations drawn up by a special commission of the 1919 Peace Conference under the chairmanship of Woodrow Wilson (see Fig. 12), the latter, then President of the United States of America, put the world into his debt. It was Wilson who was author of the famous Fourteen Points upon which the 1918 Armistice was based, and Wilson who in the fourteenth of these points declared that a "general association of nations must be formed under specific covenants." It is Wilson's finest memorial that, largely as the result of his efforts, the Versailles Treaty of 1919 did incorporate the Covenant with its historic preamble in which fifty-three nations (later increased to

fifty-eight) contracted to promote international co-operation and to keep world peace "by the acceptance of obligations not to resort to war; by the prescription of open, just, and honourable relations between nations; by the firm establishment of the understandings of international law as the actual rule of conduct among governments, and by the maintenance of justice and a scrupulous respect for all treaty obligations in the dealings of organized peoples with one another."

The Assembly was the League's parliament in which each member state had one vote. The Council was its executive, consisting of four of the five victorious great powers in the 1914-18 conflict (the United States of America did not join the League), namely, the United Kingdom, France, Italy and Japan, to whom were added representatives of four other members of the League, "selected by the Assembly from time to time in its discretion." The Council, meeting at least three times a year with each of its members having one vote and all policy (as opposed to procedure) decisions needing to be unanimous, dealt with two main problems: disarmament and arbitration.

The League's Failure

In its first ten years the League was successful in settling thirty clashes, all relatively minor, between member states. Up to 1931 and the dispute of that year between China and Japan, therefore, the League could claim steady, if unspectacular, progress towards fulfilling its task of arbitrating between member states.

Tragic years followed during which Japan's aggression in Manchuria, Italy's in Abyssinia and Albania, Germany's in Czechoslovakia — which destroyed the hopes of peace that Chamberlain brought back from Munich (see Fig. 13)—finally made a mockery of the vital Article 10 of the Covenant by the terms of which members undertook "to respect and to preserve as against external aggression the territorial integrity and existing political independence of all members of the League."

Unlike the League, the League idea did not fail. On some matters within its scope the League acted firmly and decisively; but in its declining phase it did not act effectively, for example, in the Sino-Japanese War, and the Italo-Ethiopian War, or in the Spanish Civil War. Nevertheless, its attitude was sufficiently firm to cause Japan, Italy and Germany to withdraw from the League.

The United Nations

The League is dead; long live the League! On June 26, 1945, at San Francisco, the United Nations' Conference unanimously adopted the Charter establishing an organization known as the United Nations. The nineteen chapters of the Charter with their 111 articles provide in detail for the setting up of a world body "determined," as the preamble states, "to save succeeding generations from the scourge of war . . . to reaffirm faith in fundamental human rights, in the dignity and worth of the human person, in the equal rights of men and women and of nations large and small; to establish conditions under which justice and respect for the obligations arising from treaties and other sources of international law can be maintained; and to promote social pro-

Fig. 13. *Mr. Neville Chamberlain, the British Premier, records the news of the Munich Pact on his return from Germany in September, 1938. The world hoped that the threat of hostilities had been removed, but within six months Germany's aggressions were renewed and war became inevitable.*

gress and better standards of life in larger freedom." The Charter defines the organization's organs and powers, lays down procedure for voting, sets up its principal organs of government, arranges for the specific settlement of disputes, and indicates the kind of action to be taken to meet acts of aggression and other threats to world peace.

United Nations' Constitution

The General Assembly, meeting annually, consists of all members of the United Nations, each having one vote and not more than five representatives; it is empowered to discuss all matters coming within the scope of the Charter, to settle the principles to govern disarmament, to hear any cases put before it by non-member states, and to call attention to situations threatening world peace. A two-thirds majority is necessary for any decision on a matter of importance.

Britain, China, France, the U.S.S.R. and the United States are the permanent members of the Security Council; six non-permanent members are to be elected in addition for two-year terms. The Council will sit in continuous session, and will have the advice on military matters of its own Military Staff Committee, consisting of the Chiefs of Staff of the permanent members, which Committee will, under the Security Council, be responsible for the strategic direction of the armed forces (notably national air-force contingents held immediately available for the Security Council's use) to be placed at the Council's disposal. The International Court of Justice, chief judicial organ of the United Nations, will give decisions in disputes between nations, and these must be complied with by all member states. At the beginning of 1946 the United Nations held its first session in London (see Fig. 14). The Foreign Minister of Norway,

Mr. Trygve Lie (see Fig. 15) was elected as the first Secretary-General.

The chief resemblances between the dead League and the new organization are apparent. Each has sprung from an association of powers victorious in a great war; the Security Council, as was previously the League Council, will be dominated by the great powers. In the new organization the right of veto possessed by any one of the permanent members will effectively prevent action in any dispute in which that power is involved.

If there is less idealism in the United Nations organization than in the old League, there is also less hypocrisy. Even its founders admit that its Charter is no perfect instrument, but a compromise document based on many lesser compromises. As a result, the wild hope, the too-great expectation aroused by the League has not been paralleled in the instance of the United Nations. That is all to the good.

In a world which, whatever its lip service to the principles of good will and peaceful arbitration, believes in the validity of force as an ultimate means of settling national quarrels, it is an advance that the new international body should have force at its disposal. In 1919 men thought they heard something like an angelic singing from Geneva; in 1945 they heard a good deal of bickering at San Francisco. The 1919 angelic chorus came from a fool's paradise; the 1945 international bickerings came from men who recognized their human limitations and promised no Utopia served up on celestial platters.

Facile Political Cynicism

So ends this brief account of mankind's attempt on three planes, local and national and international, by means of the art and science of

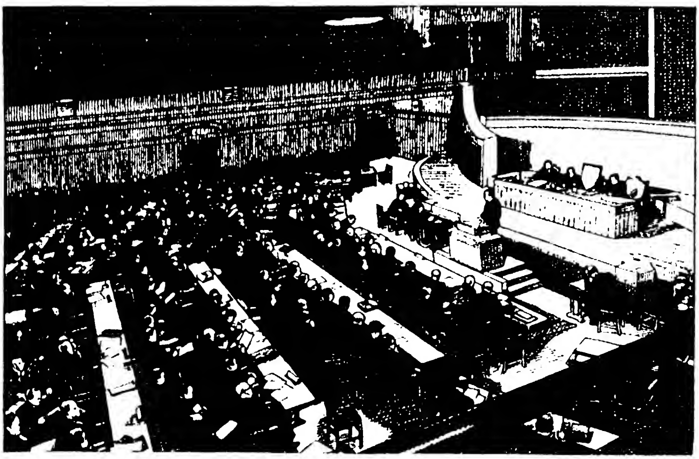


Fig. 14. *The first session of the United Nations Assembly, held at Westminster in January, 1946. The representative of Soviet Russia is seen addressing the delegates of the fifty-one member nations.*

Fig. 15. *Trygve Lie, first Secretary-General of U.N.O., and former Foreign Minister of Norway.*

politics to provide human societies of various kinds and sizes with just government, and public affairs with reasonably good administration and reasonably efficient management. Because government, wise government, has to do with the delivery to the governed of such imponderables as liberty, equality and brotherhood; and because, moreover, it is so disastrously easy to couch a series of Fourteen Points or a group of Four Freedoms, the preamble of a League Covenant or of a United Nations Charter, in noble language worthy of exalted sentiments—because of these things, the gulf in politics between promise and performance, between expectation and fulfilment, is such that the most facile of cynics can set up and knock down a political Aunt Sally with ease and apparent justification.

An election candidate's address compared with the record of his parliamentary activities at the end of a session show the same kind of disparity. Yet only a cynic will see in this a reason for dismissing politics as a trumpery business conducted by big-mouthed and dubiously honest men, compared with whom those engaged in commerce or industry, the arts and the sciences, are exemplars of efficiency, integrity and relatively silent service

The Price of Democracy

As any who has worked as a rank and file member of a political organization quickly discovers, there is more selflessness and more devotion to civic duty shown by obscure politicians of any and every political colour than is normally found in industry or commerce, art or science. Claptrap may and does too often disguise this; a political system like that of representative democracy has to be paid for at high cost — bureaucratic delays, hesitancies, over-caution; irritating governmental controls and an over-emphasis on forms and the filling up of forms are part of it. Yet he who desires a Rolls-Royce or a string of diamonds does not expect to acquire either with a pound note, whereas too often he assumes that the infinitely more valuable asset of political freedom can be had without paying its price. Thus, in the international sphere, the nations too long have asked for international peace while proposing to keep national sovereignty unimpaired.

Unless an increasing number of human beings have an increasing understanding of the possibilities and the limitations of politics as an art and a science, the tragic first half of the twentieth century will inevitably have sequels even more tragic. If the abyss is to be avoided, political mindedness, always a civic duty, has become a necessity.

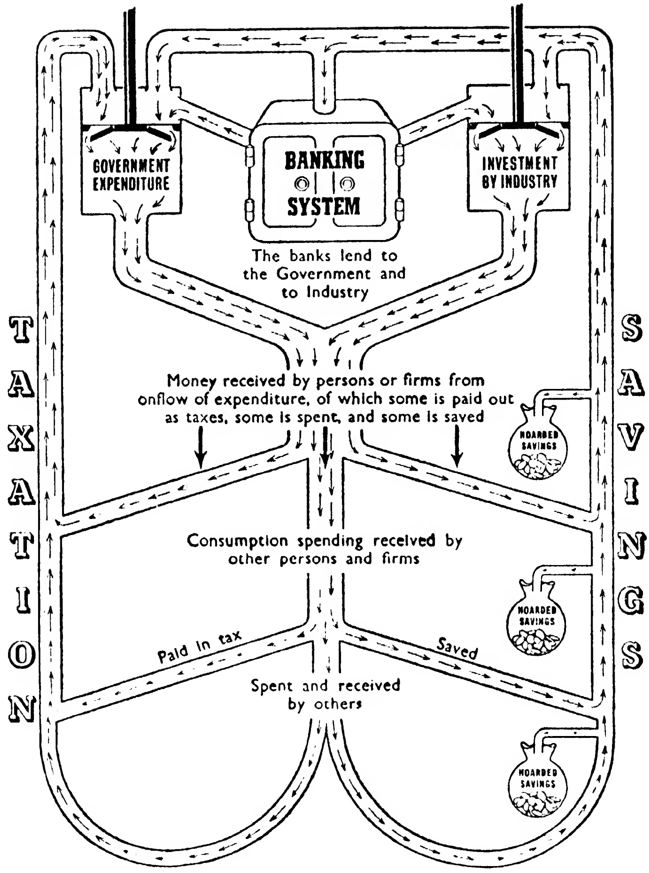


Fig. 1. *Pictorial diagram showing how money, a fundamental characteristic of all economic systems, circulates. By means of government expenditure and investment in industry money flows into the hands of individuals and firms. Recipients of the money pay some of it back to the Government in taxation. A further portion finds its way back to industry, to the banking system or to the Government in the form of savings. The remainder (apart from hoarded savings) passes into the hands of other persons or firms who, in turn, pay part as taxes, save part and spend the remainder. The banking system maintains the flow of money to the Government and to industry. Some hoarded savings (moneys which remain in the hands of those who save) eventually get back into circulation.*

CHAPTER 9

ECONOMICS IN THEORY AND PRACTICE

Field of economics. Division of labour. Use of money. National income. Economic welfare. Capital and labour. Real and money wages. Collective bargaining. Subsidies. Direct and indirect taxation. Government finance. Maintaining employment. Private expenditure. Effects of saving. Capital expenditure. Government expenditure. Labour mobility. Monopolies. Foreign trade. Rate of exchange. Imports and exports. The banking system. Nature of money. Relation of economics to current problems.

THE housewife manages the home; that involves very many jobs. She must cook; she must wash, scrub, dust, polish, make beds, arrange interior decorations such as ornaments and flowers; she must shop and look after the children, and a hundred other things. The housewife has only a limited time in which to do these things. She has to decide how much of her limited time she will devote to doing one job and how much to the others. She could spend all her time scrubbing and dusting and have a spotless house, but that would be no use because there would be no meals. If she devoted all her energies to obtaining food and preparing meals, the house would become dirty. So the housewife distributes her time between various duties in such a way that she thinks she has reached the best combination. This we call domestic economy. That is the origin of the word "economy"—the art of managing the household by the proper use of the resources, the means, the time available.

Political economy, which we also call economics, is simply this idea of management of resources and time writ large. It is the study of that part of the structure of society which is concerned with organizing the production of goods and services and with distributing them. It tells of the organizations through which individual men and women receive their incomes and through which they spend them. Our means of producing things are limited though they are for ever increasing. Looked at from some angles, economics is the study of the best use to which those limited means may be put or, as the economists say, of the "utilization of scarce means."

This, of course, involves not only the question of alternative uses, but also the question whether our resources are utilized at all. And as the utilization of material resources involves the work of men and women, it is fair to say that one of the most important matters with which economics is concerned is the question of full employment—and, of course, its obverse, unemployment.

Moreover, as all the matters with which economics deals affect us

very closely in our health, our comfort, our happiness, we are justified in saying that an understanding of economics is an essential step towards the understanding and adopting of those policies which are most likely to further the welfare of human beings as members of a civilized community.

Features of Our Economy

Amongst the fundamental characteristics of the economic systems to be found throughout the world are two which should be noted immediately. These are *(a)* the division of labour, and *(b)* the use of money (see Fig. 1).

They are characteristics which are almost always accepted as necessary parts of an economic system, whether that system, as operated in a particular country, is acceptable to us or not. They are characteristics, too, which have been part of almost all economic systems for thousands of years, though it is particularly in the last century and a half that their use has been developed.

(*a*) *Division of labour* simply means that people tend to specialize in particular jobs. Instead of performing all the duties necessary to meet the whole of his or her own requirements, each person spends his working time producing a small range of articles or services, none of which he may even desire for himself, and exchanging them for the things which he does want, and which others have specialized in producing. Rather than spend a small part of his time growing food, a further part in spinning, weaving and tailoring cloth for his clothes, and another in building his home and so on, mankind has increasingly tended to favour the system by which some grow food, some spin yarn and others build homes. Those who make shoes, say, produce far more than all of them together will require, and the surplus which remains after their own needs are satisfied can then be exchanged for food with those who have grown more food than they can consume, or for homes with those who have built more houses than they can themselves occupy.

The advantages of this specialization are fairly obvious and need little elaboration. A worker may become more skilled at one particular operation than he could on a wide range of work. He is enabled to use machinery continuously, the cost of which is less per article produced if it is kept running than if it is idle most of the time. There is much less loss of time changing from one job to another. The advantages of specialization can be multiplied, with the result that the output of a community of people is infinitely greater, thanks to "division of labour," than it would be if each person set out to meet his own needs. Think of us each starting from scratch to make the few score of pins we use each year. What a waste of time, when we consider that a relatively few specially trained operatives using machinery built by specialists, can turn out enough pins to meet all the needs of the community.

(*b*) *Money.* To make the kind of specialization we have considered a practical proposition it is essential that the products should, in every case, be readily exchangeable. To a limited extent, producers of some articles, for example butter, could exchange some of their surplus produce directly for, say, shoes with those who specialized in shoe-

making, but barter, as we call that kind of exchange, is very limited in its possibilities of application. After all, we may require tea produced at the other side of the world. Again, although the shoe-maker may require our butter, we may not require his shoes, at any rate for the time being. The device of money, the second of the two fundamental characteristics we set out to examine, enables us to get round these difficulties.

Money provides two things chiefly: a measure of value and a store of value. We may sell our produce or our services and obtain a sum of money in exchange. This sum of money will enable us to buy certain quantities of other commodities and services. To a large extent we are free to choose whether we shall use our money to buy this set of articles or that set. In other words, money, as a measure of value, has generalized our purchasing power. We are no longer compelled to accept shoes for our butter, but may take from the shoe-maker money, which will buy books instead.

Nor are we bound to spend our money immediately. We may prefer to save it for the time being. In doing so we are storing the value which was contained in the butter which we sold. It is true that money tends to vary in value at different times. The study of how and why that happens is intriguing, but for our present purpose it is sufficient to observe the fundamental roles which money and the division of labour play in our economic arrangements.

In addition to the part it plays in practical economic affairs, money is a valuable tool to the economist in enabling him to study his subject matter more easily. This can be seen clearly in the treatment of one of the subjects of his investigations —the national income.

The National Income

If we were to make a list of all the goods and services produced in this country during the course of a year, taking care not to count anything twice, such as putting down a piece of cloth as well as the suit into which it was made, we should have a picture of what is called the national income for that year. We should be viewing the national income in real physical terms. That is, in terms such as man-hours or tons of material. Such a list, however, would have to give full details of the quantities of all the different types of goods and services, which are legion. It would be so bulky and unwieldy that for practical purposes it would be useless.

But this lengthy list could be reduced to a few figures by substituting for each item on the list its money value and by adding these money values together. We could not add the number of miles of bus rides to the number of cinema performances seen — the answer would be meaningless—but we could add the value of the first to the value of the second and to that of all other similar services to obtain the total value of services performed in the year. Having added together the values of all the goods and services into one grand total we should arrive at the value of that something we call the national income. That is to say, we should be viewing the national income in monetary terms, which we designate in this country in pounds sterling (£s).

Why should we wish to produce

such a figure? What is the significance of the national income? Economics, we have said, is the study of the management of the material resources and the working time of the community; but to what purpose? In answering that question there may be some disagreement. To some it may be that the purpose to be served is the prosecution of imperial conquest; to others the securing of privileges for a particular group of individuals within the community. By and large, however, there is a measure of agreement, even amongst supporters of different types of economic systems, about the purpose of our economic efforts. That purpose is held to be the securing of a maximum amount of welfare to the largest possible number of people in the community. Therein lies the significance of the national income.

But in order to make material welfare as great as possible all round, it is generally agreed that three objectives must be aimed at.

The first of these is to make the national income as large as possible. The greater the quantity of goods and services turned out, the better off will the community be, from a material point of view at any rate. The second is to steady the national income from year to year. The experience of the United Kingdom, and of most other countries too, has been that the amounts produced have varied considerably from one year to the next. Booms have alternated with slumps; there has been full employment at certain periods (mostly war-time) and widespread depression at others. Many evils would be overcome if these variations were ironed out, even if the average of the national income over a period of years were to remain the same. The third objective is to even out the major inequalities in the distribution of the national income between the various classes or groups making up the community. A brief word about each of these three objectives is necessary here.

Maximizing the National Income

When we speak of maximizing the national income it is the national income per head that must be considered; for obviously a

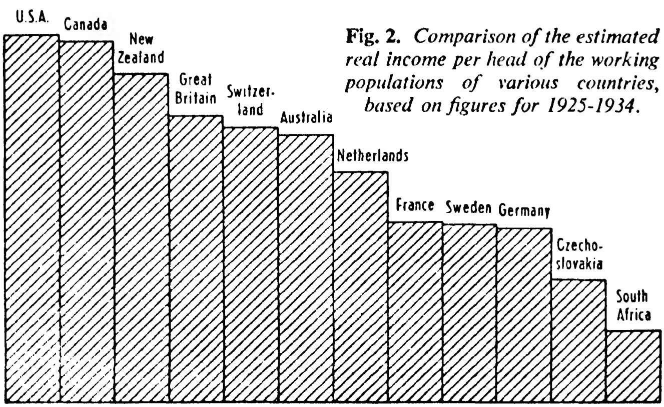


Fig. 2. *Comparison of the estimated real income per head of the working populations of various countries, based on figures for 1925-1934.*

state with a large population may have a huge national income, which may work out at a very low average income per head.

Making our output of goods and services as great as possible depends, in the first place, on the quantity and quality of what are called the factors of production. Nowadays it is common to divide these factors under the headings of labour and capital. Here, labour includes all the persons who perform work which goes into the production of an article or service, including the managerial duties involved.

In common speech, and particularly in business circles, capital is used to mean a person's or a firm's money funds or stocks and shares. In economics the word has rather a different meaning.

It is perhaps unfortunate and rather confusing that there should be two uses of the same word, but it is essential to obtain a clear picture of the way in which capital is used in economics. It covers all those *things* which give physical aid to the processes of production. Thus the stocks of material which are used, the machinery by which the material is converted, the factory buildings, the warehouses, the offices, vehicles, railway tracks, land on which these things stand or which is used for agricultural purposes, all come within the meaning of the word capital in economics. By capital goods are meant those commodities which have been produced, not because they themselves are desired for consumption, as a loaf of bread or a packet of cigarettes is, but because they are needed to assist in producing loaves, cigarettes and other consumable goods.

It will be clear that the national income will be increased if we either increase both the quantity and the quality of these factors of production or increase the one or the other. The national income per head is higher in the U.S.A. (see Fig. 2) than elsewhere partly because that country has accumulated larger quantities of capital, and this is usually of the most modern type, and therefore of the highest quality. In the early years of the Union of Soviet Socialist Republics, an unusually large part of each year's national income was set aside to swell the capital accumulation, the purpose being to make it possible to increase the national income of future years. War experience showed clearly that a nation could swell its national income by calling upon people who would otherwise not have worked or would have worked below their capacity, thus increasing the labour force (this is intended to illustrate only that the national income can be increased in this way; a community might possibly prefer leisure to material wealth).

Need for Full Utilization

The statement that an increase in the quantity of the factors of production would increase the national income needs some qualification, however. Under labour we are including management and under capital, land. It would be possible to be over-managed and it would be possible to have more land of a useless type; but there need be no reservation about the statement that an increase in the quality of any of the factors of production would be desirable. If we substitute the word efficiency for quality, we see what an important part efficiency can play in

increasing the national income and, thereby, material welfare.

Looked at from another point of view, the maximization of the national income is obviously impossible unless full utilization of the factors of production is assured. Failure to utilize the factors of production to the full—capital and labour alike—has been the principal source of waste in industrialized countries in recent years. Such waste is perhaps most vividly seen in relation to unemployment, a topic of such great importance that it will receive a good deal of attention in our later discussions.

Equalizing the Flow of the National Income from Year to Year

If a series of figures showing the national income for each of several years were to be examined, it would be seen that there were considerable fluctuations between the years. This would not mean that the volume of goods and services produced in each year had varied in exactly the same ratio as the figures in the series. Prices of the items making up the national income would probably have changed between one year and the next and the national income figure would be affected by those changes. Thus, a figure of £6,000 million one year might represent only the same quantity of goods and services as £7,000 million does the following year, if the average price of those things composing the national income rose by one-sixth between the two years.

It is possible, however, to recalculate the figure for each year as though the prices were free from variations throughout the period under consideration. Even when a

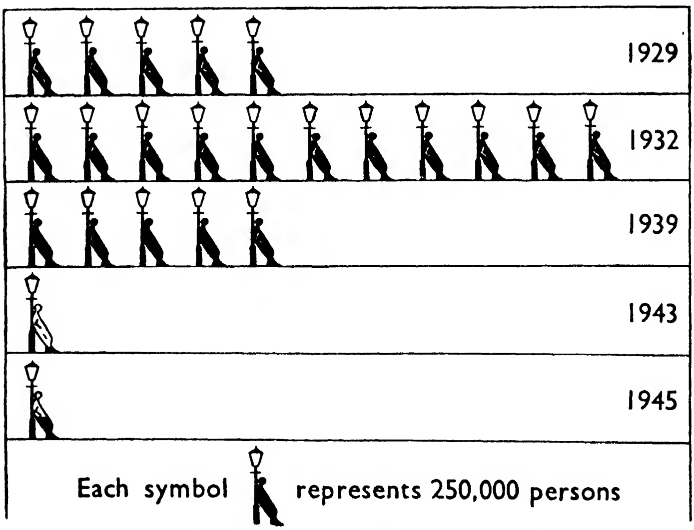


Fig. 3. *Diagram illustrating how unemployment in Britain has fluctuated at various intervals during the years 1929 to 1945.*

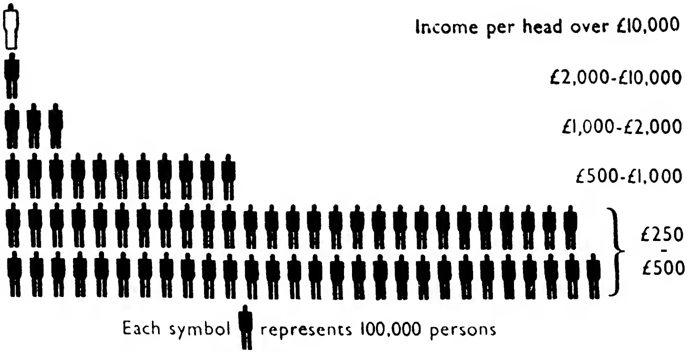


Fig. 4. *Distribution of personal income among various income groups in 1942. For every person with an income of between £2,000 and £10,000 there were about fifty-five who each had an income of only £250-£500.*

second series of figures has been obtained in this way showing the national income for each of several years calculated at constant prices, fluctuations as between one year and another would still be visible. However, the fluctuations which remain do represent changes in the real national income—the quantity of goods and services does vary in proportion to the figures calculated at constant prices.

These fluctuations arise partly from natural causes. A bumper harvest, for example, increases the real national income. Undoubtedly, however, the chief cause of fluctuations is the increase and decrease in unemployment (see Fig. 3). Once more, as in our discussion of the first objective, we come up against this question and must await a fuller treatment of it later.

Equalizing the Distribution of the National Income Between Persons

The more even distribution of the national income between persons forms the third of our objectives. There is, at present, such great inequality between personal incomes, that is between individual shares of the national income, that there is general agreement among present-day economists about the need for reduction of this inequality (see Figs. 4 and 6).

But before considering the determination of these individual shares, it would be advantageous to restate the conclusions reached, namely, that maximum economic welfare calls for an increase in the average level of the national income, and the elimination of annual variations in the level of the national income; and it makes necessary a more even distribution of the national income between the various groups within the community. Though progress toward any one of these three objectives is to be prized, the fullest measure of economic betterment for the community is only to be obtained by combining the advantages of all three.

The full utilization of the factors of production, an increase in the quantity of some of those factors, together with an increase in the

quality of all of them (in other words, a high degree of efficiency) are methods assisting in the attainment of our objectives.

Determination of Private Shares in National Income

A person's income can usually be classified under one of the following heads: Wages and Salaries, Profits, Interest, Rent (see Fig. 5), and Transfer Incomes, such as pensions, allowances from one person to another, etc. His money income for a particular year, when compared with the national income for that year, shows what his share of the total is. His money income may be greater in one year than in another and yet his share of the national income and the absolute amount of goods and services which he can command with his money income may be less in that year than in the year of his smaller money income. The opposite is also true. The explanation, of course, lies in the movement of prices of goods and services and of other persons' incomes. A distinction must be made between *money* income and *real* income of an individual, just as the same distinction was made for the community as a whole on page 338. Thus it is that we use the term *real* wages to indicate what a person's *money* wage will buy (see Fig. 2).

However, our attention is directed to the shares of individuals and groups in a particular year and to compare those shares, we must deal with *money* incomes.

Wages

Clearly the amount of wages or salaries which an individual firm or employer is able to pay its employees depends on the productivity of those employees, that is, the total output which is brought about by those employees, and upon the price which the articles produced will fetch when sold. While this is true of an individual firm, if we look at the economic system as a whole, we see that the price the article will fetch when sold depends upon what demand there is for the article and this in turn depends partly upon the amount of money

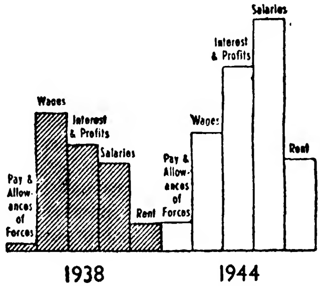


Fig. 5. *Diagram showing types of personal incomes, and the proportion of the national income which each represented, during 1938 and 1944.*

people have, that is, upon the amount of wages and salaries they are paid. We see, therefore, that there is no simple dependence of wages on productivity and price of product, because the last is dependent on the first.

While there may be some figure above which an employer will not be prepared to engage an employee, because above that figure the profit left to him would be less than would satisfy him, the wage paid could fall below what the employer would be prepared to pay rather than forgo the advantages of using the labour of such an employee. The circumstances in which this would be most likely to occur are those where the numbers of workers in a particular

occupation exceeds the number actually required in that occupation as determined by the employment programmes of all the separate employers. In that case, competition for jobs amongst the workers might force down wages. In times of widespread unemployment such as have often been experienced, wages have been reduced by this pressure and would have been reduced to small fractions of their former size if each worker had acted as an independent unit, striking his own bargain with a prospective employer. Instead of acting independently, however, most workers are banded together in trade unions which are able to strengthen the bargaining power of the workers and so not only keep the number of wage reductions low, but secure wage increases whenever possible.

The growth of trade unions has been paralleled by the growth of employers' organizations, each of which also bargains on behalf of all the employers in a particular industry. Some argue that the result is a mechanism making for rigidity and a lack of adaptability in our economic system, and it is true that this aspect has to be watched. Nevertheless, it is a stabilizing mechanism, and its absence would probably lead to fairly considerable fluctuations in wage rates, the evil repercussions of which would be far-reaching.

Effects of Demand and Supply

Although it is true that:—

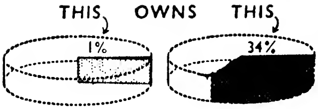
(*a*) the greater the demand for the product and the greater the demand for the labour relatively to the supply of each, the higher the wage is likely to be;

(*b*) the greater the supply of the product and the greater the supply of labour relatively to the demand for each, the lower the wage is likely to be;

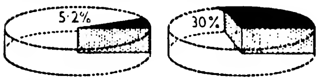
(*c*) the greater the productivity, or the contribution towards the physical output, of each worker, the higher the wage;

nevertheless, these forces do not operate freely, but are conditioned by the relative bargaining strengths of the workers and employers in determining the level of wages. It is true that bargaining strength itself depends partly on these external factors of supply and demand, but it also depends on the internal strength of the bargaining organization, on legislative action by the Government and on the bargaining organization's ability to alter the demands and supplies over which it exercises some influence, whether it be trade union or employers' organization.

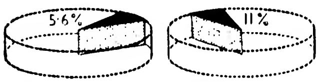
From what has been said above it will be clear that one of the factors governing the shares of many workers in the national income is the results of direct negotiations between workers' representatives and employers' representatives. The results so arrived at decide the division of that part of the national income accruing to the industry in question between workers and some of the salary earners on the one hand and those who receive profits, rent or interest from the industry, generally referred to as capitalists, on the other. Quite naturally, therefore, there is, over much of our industrial life, something of a conflict between these two groups. Attention is sometimes drawn to the danger of another conflict—that which would arise if the workers and capitalists in an industry came to an agreement to restrict the supply of their product



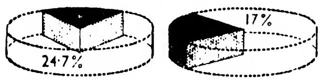
Estates of more than £50,000 numbered but 1% of the total number of estates (of more than £100) but together equalled 34% of the value of all estates.



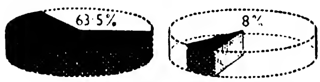
Estates of £10,000 to £50,000 numbered 5·2% of the total number of estates but represented 30% of the value.



Estates of £5,000 to £10,000 numbered 5·6% of the total number of estates and represented 11% of the value.



Estates of £1,000 to £5,000 numbered 24·7% of the total number of estates and represented 17% of the value.



Estates of £100 to £1,000 numbered 63·5% of the total number of estates and represented 8% of the value.

Fig. 6. *Ownership of property in Britain. "Estate" means the value of all a person's possessions as assessed for the purposes of death duties in 1938-1939. The diagrams show that more than a third of all the property was owned by a group representing only one-hundredth part of the total number of estate holders, while some two-thirds of the estate holders shared between them only 8% of the property.*

and so obtain a higher price for it from the rest of the community. The division of the proceeds between the workers and the capitalists might then become of secondary importance and the conflict might resolve itself into one between all with interests in an industry and the rest of the community.

We mentioned above that government legislation might play its part in deciding the division of the national income. This is particularly the case in some industries where the workers were too weakly organized or which were unprofitable, relatively, that is, to other industries. In some industries legislation has established special bodies for wage fixing, some of them known as Wages Councils. Innumerable other arrangements have been made for establishing the share of the worker. Many, particularly salary earners, arrive at their remuneration by individual negotiation with the employer, although over this area, too, the trade unions have made considerable advances and have in numerous cases obtained standard remuneration for certain occupations.

Other Incomes

Those who receive incomes other than by working for an employer usually do so by virtue of owning property in one form or another, although there is a large class of professional workers, such as lawyers and accountants, as well as working proprietors of some businesses, who do not work for an employer nor are yet dependent on the ownership of property. Such property may be in the form of land, of houses or other buildings, of stocks or shares in an industrial

or commercial concern, or of money lent to individuals, banks, government agencies, etc., on which interest is paid (see Fig. 6).

Here again the influences of supply and demand and of productivity play their part. Thus the income obtained by letting furnished rooms is likely to be greater in time of housing shortage, when the demand for such rooms has increased many times more than the supply has done—when, in fact, the supply may have decreased. Again, however, these are not the only influences at work. Bargaining power is another such influence and although this depends partly on the demand for and supply of the type of property being considered, nevertheless it is also partly dependent on the knowledge and astuteness of the parties to the bargain, and of the resources behind each party. There is much more individual action and much less organization about it than in the case of wage bargaining. Government action also plays its part in many directions, as in the Rent Acts, requisitioning and the like. In the case of the rate of interest, which is the remuneration for parting with "liquidity," as it is called, the Government has almost a 100 per cent say.

The fees charged by professional firms for their services are much less influenced by factors of supply and demand, chiefly because the various professions are thoroughly organized into representative bodies, whilst the clients are unorganized and powerless. Those proprietors of other businesses which are not dependent on ownership of property, are usually persons classed as "employed on own account." Their remuneration is probably as much responsive to changes in demand for their services as any type of remuneration.

Transfer incomes, in so far as they are pensions or insurance payments made by the Government may be increased or decreased in response to popular feeling expressed through Parliament.

Redistribution of Incomes by Taxation and Subsidies

This discussion has given us a general idea how the first distribution of the national income is made. The distribution which is thus arrived at is not final, however. The persons who receive the incomes are subject to taxation, which may be levied by the central Government or by a local authority in the form of rates. By taxation a portion of each person's share in the national income is taken away (see Fig. 1). The Government, central and local, engages in expenditure chiefly in the provision of services which are enjoyed by all. This again involves a redistribution of the national income. Sometimes the government expenditure is in the form of subsidies which keep down the price of particular commodities. It is unlikely that the commodities are bought by persons in exactly the ratio as that in which they pay taxes to meet the subsidies. This, then, is another aspect of redistribution.

The taxes which are levied may have widely differing effects from a redistributive point of view. Broadly they fall into two classes—direct and indirect (see Fig. 7). Direct taxes are those such as income tax and death duties, which are levied on a specific person or his estate. In Great Britain, such taxes are of the kind called progressive:

this means that the higher the person's income or the greater his estate, the greater is the percentage of it which he has to pay in tax (see Fig. 8). These are the taxes which, from the redistributive point of view, are most effective, since they take most from those whose share in the national income is greatest. Indirect taxes are those levied on particular goods or services such as import duties, purchase taxes or entertainment taxes. People purchase such things as tea or cinema tickets to an extent which bears no close relationship to their incomes, unless they are very poor indeed. The amounts of this type of tax paid by those with large original shares in the national income are not necessarily greater than those with small shares. Consequently the redistributive effect of indirect taxation is smaller than that of direct taxation.

A more even distribution of the national income is the third of our objectives designed to increase economic welfare: we have, therefore, grounds for preferring direct taxation to indirect taxation. Perhaps the strongest objection against any large transfer from indirect to direct taxation on the part of the Government is the possible deterrent effect on effort and enterprise, when the more one earns, the larger proportion one pays. Some may not feel it worth while to earn an extra £1 if 9s. of it is taken away. We shall see, however, that not only is direct taxation preferable for its own immediate effect of redistribution, but it is also preferable as a means of minimizing unemployment and so maximizing the national income, which is one of our objectives. It also follows that the advantages of direct taxation are lessened at times when employment is plentiful.

Before dealing with the question

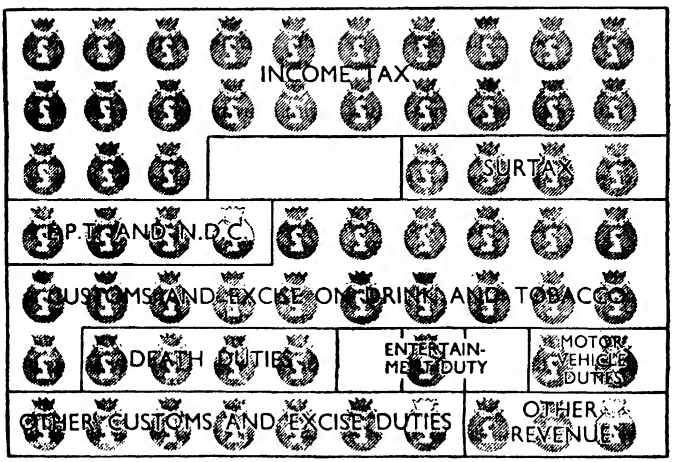


Fig. 7. *Diagram showing the various types of direct and indirect taxation contributed towards the central Government's revenues in 1940.*

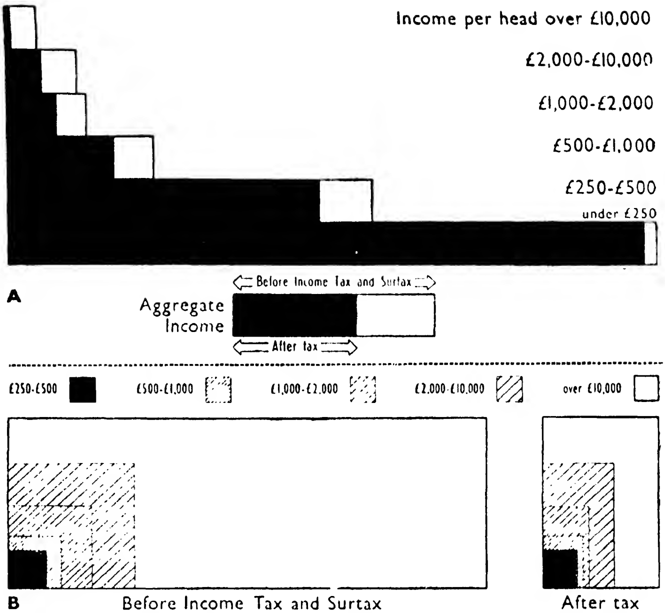


Fig. 8. *Two diagrams which illustrate the incidence of Income Tax and Surtax on income groups in 1942. Diagram* A *shows the distribution of personal incomes between income groups and the proportion of each group's income taken by the Government in Income Tax and Surtax. Diagram* B *shows the comparative size of an average income in each group before and after the deduction of Income Tax and Surtax.*

of full employment of our working population, material and machines as a method of maximizing the national income and of reducing its fluctuations from year to year, we must say something about the finances of the Government.

The Government's Finances

The Government, like an individual, a firm or a society, receives money and spends it and it might be thought on that account that the Treasury, which looks after the Government's purse, should be chiefly concerned with seeing that it did not spend more than it received. This is not so. The Government's first objective must be to pursue a policy designed to make the list of goods and services—the national income—as big as possible. Its policy must make full employment possible. Its second objective must be to do what it can towards redistributing the national income. If the Treasury puts these two objectives first, the result may be that it spends more than it receives. Such a statement is startling to most

people who are used to managing their own affairs prudently. "Can't be done," is the first reaction. "Where would I be," they might say, "if I did that? Bankrupt!" The Government is not, however, in the same position as we are. We have to earn pounds or win them or steal them, or come by them in one way or another such as these. We cannot manufacture them—at any rate, not without running the risk of imprisonment—but the Government can, whether in the form of notes or in the form of bank credits.

Government Creation of Money

The statement that the Government can manufacture money requires close examination because there are objections often raised against the use of such methods which should be answered. One objection is that the result will be that prices begin to rise, which is an undesirable thing. This is true only if all the workers and resources of the country are already fully employed. In that case, if the Government were to create more money and "spend" it into circulation, the people would have more purchasing power, but no more goods and services to purchase. Unless people saved the additional money, prices would rise even farther, because more money would be spent on the same amount of goods. But if workers and resources are fully employed already—as we supposed they were in raising the objection—then there would be no necessity to create money as part of a policy for securing full employment — we would already have full employment.

Suppose we started from a position where there was appreciable unemployment of workers and resources and that, as part of the Treasury's financial policy for wiping it out, the Treasury spent more than it received from taxation—"deficit financing" as it is called. Would not that cause prices to rise? If there were to be any rise in prices, then it would immediately pay someone to set some of the unemployed workers and resources to work producing goods for sale at this slightly higher price. The principal effect of this financial policy would be to cause increased employment so long as there existed appreciable unemployment. The nearer the economic system gets to full employment, the greater is the danger of prices rising rapidly as the result of this financial policy. The objection raised is not a valid one because prices only begin to rise appreciably when the first objective of our policy—full employment—has been achieved.

We have, so far, spoken of the Government creating money to meet the difference between its income and its expenditure. This it need only do from time to time and as a temporary measure. First of all, we must notice another difference between the Government's finances and our own individual ones. The more the Government spends, the more it receives. If it started a new programme of building and created money to pay for it as a first step, that money would be paid out to all the workers and shareholders in the firms employed in the programme. Each of the recipients would pay tax on his earnings and the revenue from such taxation would find its way back to the Government from whence it had come. Further, when the recipients spent their incomes they would buy

goods and services on which, in all probability, there would be some tax, which again would go to the Government. In addition, all those who received the spendings of the original recipients would pay tax on income and on their purchases and so on. Thus the Government would receive back a considerable part and to that extent it would be able to reduce the amount of money it had originally created. The amount of expenditure which the Government did not receive back as taxation would be exactly equal to what individuals and companies had saved as the money passed through their hands.

To remove the danger that those who have saved this money (which has been "spent" into the public's hands by the Government) might try to spend it when full employment has already been achieved, the Government might sell savings certificates and other such securities. This draws the money out of the public's pockets and, although it is easily obtained by them again by cashing the certificates, they are in this way discouraged from spending.

This method of reducing the upward pressure on prices involves the danger that all holders of government bonds and certificates may wish to cash them and spend the money thus obtained at one time. If that were to happen, the rise in prices which we sought to avoid, would occur. In practice, there is such confidence in the enduring value of government securities, that a widespread attempt to exchange securities into cash has not been made in this country.

To keep the danger of such an occurrence as small as possible, the Government might increase the rates of taxation, thereby reducing the deficit—the gap between its income and its expenditure. To say that is not to deviate in any way from the assertion that the balancing of its accounts is not the primary objective of the Treasury's policy. Increased taxes are only suggested to meet a situation which might arise when the first objective—full employment—has been achieved.

The National Debt

Here we may deal with a second objection to our suggestion that the Treasury should not be primarily concerned to see that its expenditure does not exceed its receipts. Is not the growth of the national debt merely postponing the evil day? Are we not pushing our burdens on to future generations? Let us answer the latter question first.

Think again of the list of goods and services produced in a particular year. Each year starts with a carry-forward of goods (some in the form of property, machinery, etc.) from the previous year. Unless, in the year under consideration, we use more than we produce, that is, unless we pass forward to the next year less than we received from the last one, we have in no way burdened the succeeding generation. A money deficit at the Treasury is in no way the same as using more than is produced in a given period. The national debt simply means that money is transferred from one set of people in the country—the taxpayers—to another set and called "interest." In fact, the receivers might be the same people as the payers, though it is unlikely that they would receive just the same amounts as they pay for that purpose. Payment of interest on

the national debt involves a redistribution of the national income amongst a particular generation, but it does not mean that one generation is paying for another generation's imprudence. We are in no way "postponing the evil day." So much for the objections raised against the first objective of Treasury policy.

There is a third use to which the policy of the Treasury may be put. It may exercise considerable influence over the proportion of our annual output—the national income—which we consume as we go along, and the proportion which we set aside to replace depreciating machinery and other equipment, in other words, capital investment, which will assist us in producing future national incomes. This aspect of public finance will be better understood when we have discussed employment more fully.

To recapitulate our argument, the primary object of the Treasury policy should not be to make income and expenses agree—"balance the budget"—but to facilitate the full employment of workers and resources. As secondary objectives there may be the control of the division of national income between consumption and investment and the redistribution of the national income between groups of persons. In pursuing these objectives the chief danger to be watched is that of rising prices—inflation—which may occur when the first objective of full employment has been achieved and in order to meet this

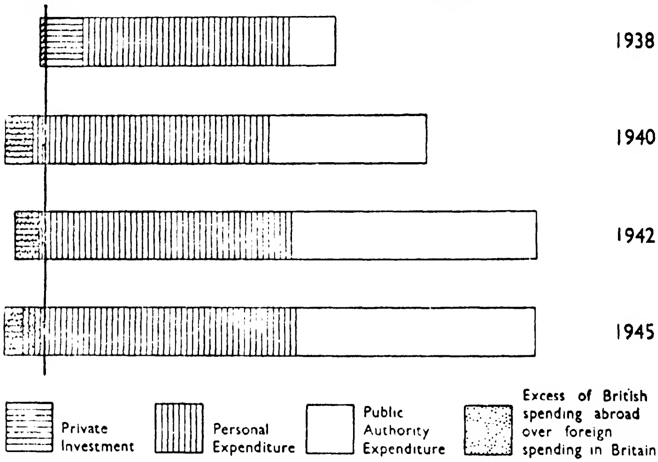


Fig. 9. *Diagram showing the four main types of spending in Britain. In each of these four years the amount of foreign money spent in Britain was more than offset by British spending overseas, with the result that balances of British spending, shown by the dotted areas left of the vertical line, went abroad and did not contribute to the maintenance of employment in Britain.*

the Government may then employ various devices, such as additional taxation, savings campaigns, price controls, and so forth.

Employment

We have said that economics is concerned with the material welfare of the people. We have suggested that, in order to improve that material welfare, it is necessary to make the sum total of goods and services produced as large as possible, to make the variation in that total from year to year as small as possible, and to divide the total between people, at any rate more evenly than at present. We have discussed the methods by which the share of each person is determined. We have stated that one important way of increasing the total is to increase the efficiency of the factors of production. Before we can increase the number of units of each of the factors of production, or ensure that these are fully utilized; before we can remove the chief causes of year-to-year fluctuations and increase the shares of those whose shares are least—all of which would lead to greater economic welfare—we must know how to secure full employment.

By full employment we do not mean that every person and every piece of equipment is employed all the time. If we confine ourselves to the full employment of *persons*, it is generally agreed that we would have full employment even if anything up to three persons in a hundred who seek jobs were out of work at any particular time. Such persons would be in the process of changing from one job to another and so on. By full employment is meant that at any time there are more jobs waiting to be filled than people wishing to fill them.

What generates employment? What causes it to be offered? It is roughly true to say that employment is created when money is spent. Not all spending generates employment, however. The mere transfer of ownership through buying and selling of something such as shares in a business does not do so, but for our present purpose we can broadly identify employment with spending. The problem of maintaining full employment, then, becomes one of maintaining spending (or effective demand, as it is called) at a sufficiently high level. As we have seen, we do not want to push spending beyond the point where there is already full employment, otherwise the result is merely to increase prices, but as peace-time experience has been that total spending is usually well below that level, we can concentrate on analysing what decides how much is spent. For this purpose we may divide the amount spent in this country into four main types (see Fig. 9):—

(1) That spent by the general public in their individual capacities. This usually comes under the heading of consumption expenditure since it is generally intended to purchase such things as food, clothing and entertainment, which are used up immediately or over a period (see Fig. 10).

(2) That spent by industrial and commercial organizations for the purpose of increasing their capital, which includes, besides productive equipment, stocks of material, etc.

(3) That spent by public bodies (central and local governments, etc.) for ordinary administrative

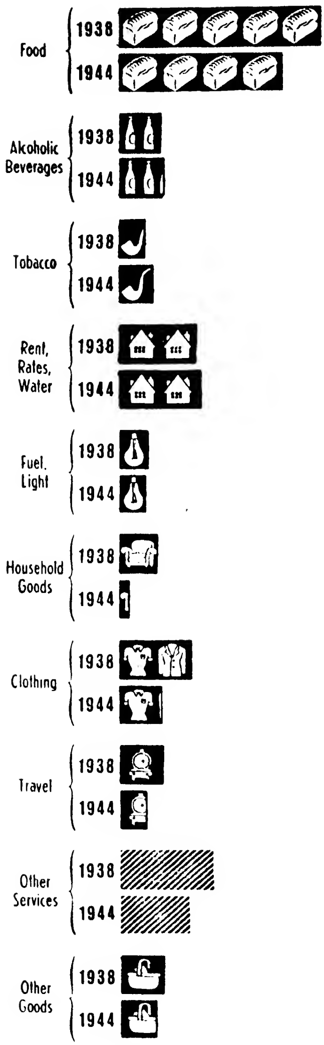


Fig. 10. *Diagram comparing the purchases of consumer goods and services in 1938 and 1944.*

purposes, the construction of capital equipment or the production of services.

(4) That spent by people in other countries in purchasing our goods (our exports) to the extent that it exceeds what our people spend on goods produced abroad (our imports). For example, if a person in this country buys an article for £5, the article having been imported by a merchant for £4, the employment generated in this country is only equivalent to the spending of £1 (£5 minus £4) but the whole of the £5 will have been added into our total of consumption expenditure for the country. Therefore, we have to deduct the value of imports to find out what the employment-generating expenditure is. Similarly, we have to add the value of the goods we export to obtain a guide as to how much employment there will be in this country. If exports exceed imports, there will be a net balance of employment created. This is sometimes called an "active" or "favourable" balance of payments on current account, but it is only favourable in the sense that it creates employment. Consumers in this country do not receive the products of that employment.

Private Consumption Outlay

We may examine each of these types to see what determines its size. That of the first type, which may be described as private consumption outlay, is largely determined by the size of the other types. The spending of most individuals is dependent upon their incomes and

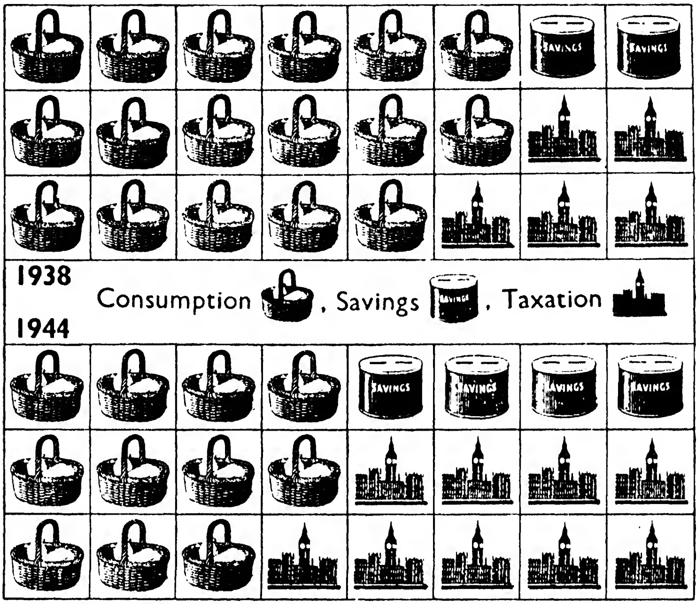


Fig. 11. *How private incomes were allocated during 1938 and 1944.*

these are likely to be higher, taken on the aggregate of all individuals, if there is greater employment generated by the other types of spending than if there is less. Nevertheless, with a given level of employment arising from the other types, private consumption outlay can vary and thus exercise its own influence on the total level of employment. This is because every individual who receives an income is free to some extent to choose how he shall use it. He may spend it or he may save it (see Fig. 11). If he spends it, he is creating employment (unless there is full employment already), and thus increasing the national income. If he saves it, he is not creating employment.

This may be illustrated by supposing that the Government has embarked on some new project necessitating considerable expenditure (our third type of spending). The project may be for any purpose —perhaps a barrage across the River Severn. We may suppose that ten thousand workers are employed, directly on the site, and indirectly, producing materials, etc. If these ten thousand workers receive an average weekly wage of £5, £50,000 will be passing into the hands of wage-earners each week. If, on an average, each worker saved one-fifth of his income, that is £1 per week, £10,000 would be saved and £40,000 would be spent at shops, at places of entertainment, on buses, etc., or paid to the Government as taxes. There would be a whole

range of persons and organizations employed in meeting the demands represented by the £40,000 and these persons would receive the £40,000. In their turn, they might be expected to save £8,000 and to spend £32,000. Another set of workers, shareholders, shopkeepers, etc. would receive the £32,000 and if they were to behave as we have supposed the others to behave—to spend and pay in taxes four-fifths of their income and to save one-fifth—they would spend £25,600 and save £6,400. This process would be repeated, the amount spent at each stage becoming smaller as more and more of the original £50,000 came to rest in someone's pocket or bank account or returned to the Treasury (see Fig. 1). Ultimately, the amounts saved, including that saved by the Government (£10,000+£8,000+£6,400, etc.) would total £50,000, the amount originally spent on the supposed project. The total amount spent by everyone receiving money as a result of the project (£40,000+£32,000+£25,600, etc.) can be shown mathematically to total £200,000. If we are trying to estimate the total employment caused, we should add on the £50,000 spent by the Government in the first instance, and obtain the figure of £250,000 representing what we might call "employment-generating expenditure."

Effects of Increased Saving

Let us suppose that instead of saving one-fifth and spending four-fifths of what he or it receives, each person or organization whose income is affected is inclined to save a greater part, let us say two-fifths, and to spend a smaller part, three-fifths. Those who were the immediate receivers of the £50,000 would save £20,000 and spend £30,000. Those who received the £30,000 would save £12,000 and spend £18,000. At the next stage, £7,200 would be saved and £10,800 spent. Once again, the process would go on until the whole of the £50,000 had been saved by someone. The amounts saved (£20,000; £12,000; £7,200; etc.), are larger in the first "rounds" of the second example than they are in the first, but they taper off much more rapidly and in both cases, the total amount saved is the same, namely £50,000, which is the amount originally spent on the project.

The total amounts spent at all stages in the two examples are not the same, however. In the first example, where we supposed each person saved one-fifth of his income, the total spending amounted to £250,000, but in the second example the equivalent figure is £125,000.

Although the persons and organizations in the second example were more anxious to save a larger part of their income than those in the first example, in fact they saved exactly the same when taken together. On the other hand, when the inclination to save was greater, the total amount spent was less.

The reason for this result is that the more one person saves, the more other persons' incomes are reduced below what they would have been if the first person had saved less. Even if the person who had increased his saving were to lend the money thus saved to someone else who would spend it, our conclusion is not invalidated, because those who had their incomes reduced by the saving would not now be in a position to make similar loans. The total savings—

out of which such loans could be made—remain the same, and are determined by the expenditure coming within the second, third and fourth classes of spending given on pages 349-350.

All this does not mean that any one individual is not able to decide to save more. Most definitely he is, and to do so may be in his own best interests, but his decision decreases the savings of others, because their incomes are reduced.

Two guides to policy emerge. First, if unemployment exists and it is desired to be rid of it, the public may be encouraged to save less. The result will be that just the same amount is saved in total, but more will be spent in the course of saving that amount and thus more employment will be created. Second, if there is no unemployment, the upward pressure on prices which accompanies such a situation can be reduced by encouraging people to save more. The result will be that no more is saved in aggregate, but less is spent in the course of the same amount being saved. In war-time and other periods when workers and materials are not so plentiful as to satisfy the demands of the public for goods, the Government organizes savings campaigns, not because it could not carry out its programme if we did not lend it money, but because in that way it can reduce spending by the public and thus diminish the risk of rising prices.

Whilst it is true, then, that the type of spending known as private consumption outlay is largely determined by what individuals receive as a result of the other types of spending, nevertheless, individuals have the power to increase or diminish private consumption outlay by saving a smaller or a larger part of their incomes. By so doing, they do not diminish or increase the total savings of the community but they do diminish or increase the total spending generated and hence the employment given. Examination of statistics relating to the subject reveals what one would expect, namely, that on the whole, the higher a person's income, the larger the proportion of it he is likely to save. Those with small incomes and little to spare above what is necessary to buy the essentials of life, save little or nothing. Our object being to discover what generates spending, we see that the latter would be increased if we could take away part of the incomes of those receiving most and hand it to those who receive least, for in that way would we ensure an increase in the over-all rate of spending and a decrease in the rate of saving. We can connect up this finding with the statements made earlier on the redistribution of the national income as a means of achieving economic welfare. The favouring of the greater-spenders at the expense of the greater-savers is one way to full employment, but we are likely to find other, perhaps easier, ways when considering the other types of spending. This is particularly so if it should be decided that it is desirable that we should prepare for the future by devoting more of our national income to capital investment and less to current consumption.

Capital Expenditure

Now let us examine the category of spending we have called capital expenditure by firms, and try to find out what determines its size. The purpose of the vast majority of

commercial and industrial concerns privately owned and directed is to make as large profits as they possibly can. Many have other, secondary, purposes, but, on the whole, when a new project is being considered, it is the prospective profit arising from it over a number of years which is likely to determine whether or not the project is undertaken. If the board of directors of a company is deciding whether to undertake extensions to the company's premises, it will be the additional profits they expect to be able to make, compared with the cost of extension, which will make up the board's mind. It does not matter, at the moment, whether the prospective rate of profit would have to be five, ten, twenty or more per cent in order to cause the board to think the expenditure worth while, but there would be some such figure. One of the factors in deciding the total extent of capital expenditure by firms is, then, this estimation which each firm makes.

Estimating Trade Prospects

Estimations of future profits cannot be calculated accurately, one of the big factors being the state of trade over a period extending many years ahead. If trade is expected to be good, if unemployment is expected to be low, profits may be expected to be higher than they would be otherwise. Such expectations would lead to increased capital expenditure being undertaken and so to greater employment and larger profits. Thus, the mere fact that the state of trade is expected to be good in future would tend to make it good, and as the expectations were realized, still more capital expenditure would seem to be justified. On the other hand, if prospects appeared poor, boards of directors would be likely to embark on fewer projects of capital expansion. As a result, employment would fall off, trade would slacken, and the directors would feel justified in the estimations they had formed. There is, then, an element of instability in economic systems where independent individual decisions are made about capital expenditure. If a slump in employment is occurring, then unemployment tends to grow worse. If a boom in employment is growing, then employment tends to keep on growing.

If these were the only tendencies at work, we should soon reach one extreme or the other, but there is at least one major tendency working in the other direction. When a board of directors is making its estimation of the prospective profit of a particular project it has to take into account not only the future state of trade, but also the number of plants producing similar articles with which the proposed project will have to compete. The fewer competing plants there are, the more likely are the profits to be high and hence the more likely is capital expenditure to be incurred. The more competing plants there are, the less likely is the proposed project to be carried out.

When we take this tendency into account in conjunction with the tendency mentioned previously, we have a situation where expenditure in capital equipment stimulates more expenditure of a like kind, and that process goes on until so much capital equipment has been accumulated that further additions to it become unprofitable. The process is then reversed and the decline in this type of spending

continues until the amount of capital equipment has been so reduced that more profitable opportunities for new capital have opened up. It might be asked whether the financial resources of the firm contemplating expansion of its capital equipment do not play a part. There may be differences of opinion on this point, but while it is true that those financial resources play some part—that is to say, the greater the resources, the more likely is the firm to embark on expansion expenditure—it is also true that if a firm has a project in mind with a reasonable prospect of good returns, it can generally borrow funds with which to finance the project. As we shall see later, the Government is in a position to control financial policy in such a way as to ensure that the banks and other institutions are always able to finance firms (see Fig. 1). Such financial assistance costs the borrowing firm something—the interest on the amount borrowed. The lower the rate of interest, the more likely are we to encourage capital expenditure by firms.

In order to keep this type of spending high, the Government must ensure that the other types of spending are kept high, for then will prospective profits be high unless a point is reached where the contraction effect of a large capital stock exceeds the expansion effect of a high level of spending. In that case, total expenditure can only be maintained if the Government increases its own expenditure.

Government Expenditure

The Government's expenditure, which we listed as a separate type, is accounted for by spending on a variety of services, such as administration, the rapid expansion or contraction of which, in order to utilize more fully or to free resources or manpower, is not desirable.

Government expenditure could, however, be increased on many desirable and badly needed works and services. We have seen in a previous section that the Government need not be deterred by the financial aspects—it only requires to know whether men and resources are available for the scheme. It is in this category of government expenditure that we have to look for opportunities to maintain total spending of the community at a high level. Not only will an increase in government expenditure add to the total itself, but it will have the secondary effect of increasing consumption expenditure of individuals and it will so improve prospects that, temporarily at any rate, it will increase expenditure on capital equipment by industrial and commercial concerns. If such capital expenditure later falls off, it may be necessary for the Government itself to enter the industrial world. It may not be profitable to independent firms to embark on a project, but it is obviously better for the community that the project should be carried through rather than that men and resources should be idle.

The fourth type of spending—the excess of the value of exports over the value of imports, will be discussed later.

We have discussed the question of maximizing economic welfare by utilizing all our manpower and resources, that is, by securing full employment, and we have treated it as though it were purely a matter of maintaining the total spending

of the community at the appropriate level. By doing that, we have assumed that if there were a fall in one type of spending it would be fully compensated by increasing spending of another type. This is *not altogether* a correct statement of the position. Capital expenditure by firms may decline and, as a result, workers and equipment in the engineering industry may be thrown out of work. We may endeavour to counteract this by taking steps to redistribute the national income in favour of the lower income groups who spend a greater part of their income. This additional "consumption-spending" may not, and probably would not, be on goods and services produced by the engineering industry, which now has unemployed workers and equipment. The situation which we wished to correct is, therefore, left untouched. Even if the spending we had generated by our measures were on the correct type of goods or services, the increased spending might occur in a part of the country where the resources for meeting the demand were not available. Thus, the fact that public works employees and equipment are available in one part of the country would not satisfy a demand for the same things in another part of the country. Unless labour and capital are mobile, our full employment programme may be thwarted.

Labour Mobility

Technical evolution makes labour immobility a very real problem. By the introduction of inventions and improvements there are always some industries which are declining and some which are increasing in their demand for labour. In other industries the separate firms may find it cheaper to operate in a different part of the country from that in which they have operated hitherto. Where there is unemployment which we are endeavouring to remove, it may not be possible to offer a man work of the kind in which he is skilled.

This may not be as serious a problem as it might seem at first. A review of the occupations of the working population over a period of years shows that we have considerable powers of adaptation which have resulted in notable increases and decreases in the numbers engaged in each occupation (see Fig. 12). In part, however, that is due to the economic pressure put upon unemployed persons to change their occupation and residence. If this pressure is reduced, which economic welfare demands, immobility of labour may increase. The dangers of geographical immobility may not be as serious if the considerations taken into account in locating industry are widened. Those that do exert an influence relate largely to operating costs of a particular firm, and under these conditions immobility of labour geographically may be very serious. It should be remembered, however, that when, say, a new factory is established in, or on the outskirts of, a large urban area, because, for example, the transport costs of the final product are least at that point, there is an additional cost to all the firms already established in the area owing to the increase in pressure on all the services, for instance, through increased congestion on the roads. The same increase in cost (and in inconvenience) is also added to all the individuals who work in the area. There is, in addition, the

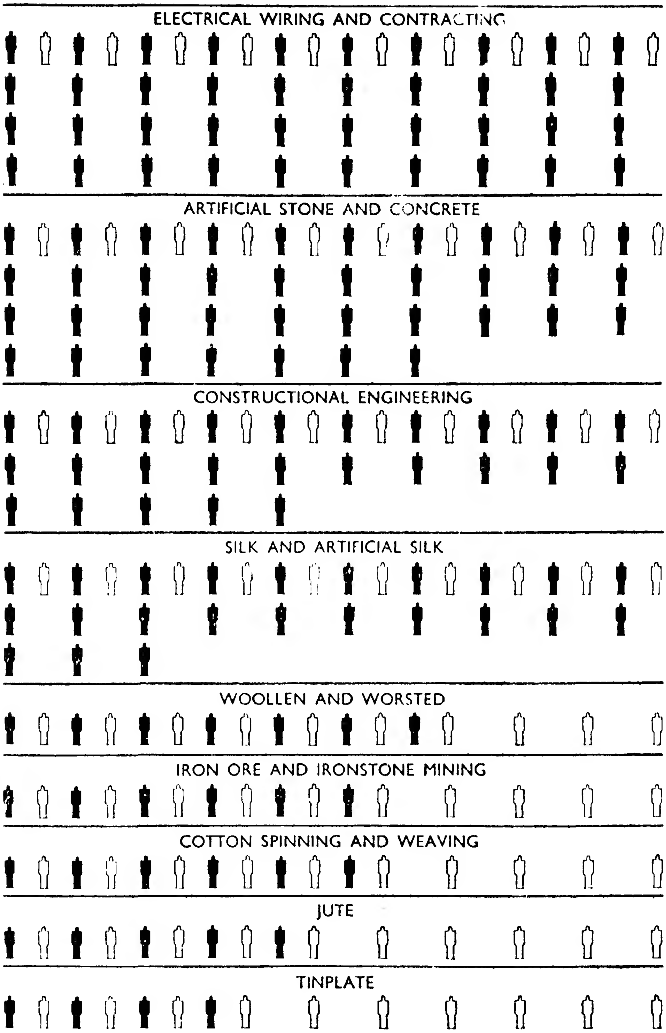


Fig. 12. *Expanding and declining industries. The ten white figures under each industry represent that industry's labour strength in 1923. The black figures show the alteration in labour strength by 1938.*

waste arising from the redundancy of the services provided at the place where reduction of industry has taken place. If we substitute the best interests of the community as a whole for the financial interests of a particular firm as the criterion by which to decide policy, we can see that it may often be best to establish units of a growing industry in districts which have previously depended on industries now declining, or which are too dependent upon one or two industries only. The particular community is not allowed to degenerate into a depressed area and the workers are not compelled by force of economic circumstances to go to other areas, a process which tends to take away the younger and more energetic workers, leaving the older ones behind. Full use is made of what might be called the "social capital" already established in the district.

Influence of Monopolies

The policy of increasing and maintaining employment by raising the total spending of the country, may also be undermined if there are extensive private monopolies controlling the trade of the country. A monopoly involves the exclusive trade in a particular commodity or within a particular district by one firm or by groups of firms acting in agreement. In practice, no firm has an absolutely water-tight monopoly, as there is always competition from substitute commodities to some extent. On the other hand, there is no such thing as the opposite of absolute monopoly—perfect competition—which would be a state of affairs in which the price charged by each firm for its product would be no more than the cost of production. Monopolies are, in fact, fairly widespread in Britain (see Fig. 13), and prices paid for certain goods and services are consequently in excess of what they would be if there were more effective competition between firms. In this situation, our efforts to keep at the necessary high level the total spending of the community may result, not in increased employment, but in increased prices. Our pursuit of economic welfare, therefore, demands all steps for the strict control over, or even the elimination of, privately controlled monopolies.

Foreign Trade

Very little has so far been said in our discussion about the trade which is conducted between one country and another. For most of the time we have treated a country as an entirely separate economic unit. A country for this purpose is defined as an area in which there is a central monetary authority, armed with powers of taxation and of legislative control of various aspects of the economic system. In practice each country is far from being a separate economic unit; each is, in fact, to a greater or lesser extent, dependent on goods and services produced in other countries. This is partly because some countries are entirely devoid of certain materials, or are totally unable to produce certain commodities. In the main, however, it is the relative costs of producing things which can be produced which give rise to the exchange of products which we call international trade. The cost we speak of here is the cost to the individual firm or producer, and is not necessarily the cost to the country as a whole.

Let us consider the ordinary course by which international trade

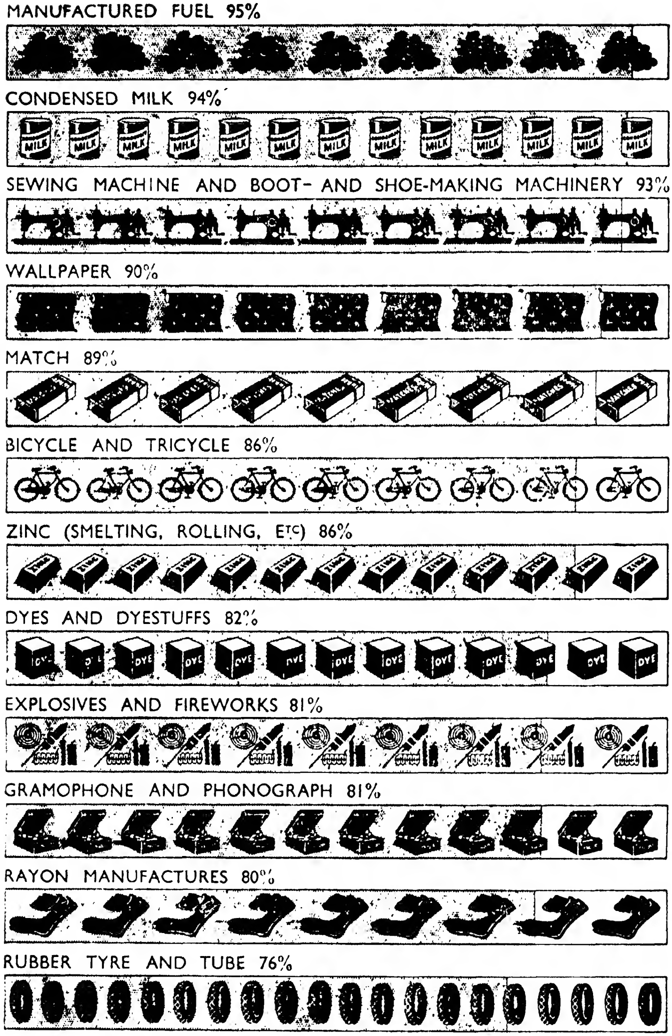


Fig. 13. *Extent of monopoly in certain trades. The percentages after the descriptions correspond with the shaded portions of the diagrams, and show the extent of the output accounted for by the three largest units in each trade.*

arises. A person in Britain goes to the cinema. Many of the films shown at British cinemas are United States productions. This is partly because there is a considerable demand for certain types of film which British companies, for one reason or another, do not produce, at any rate in sufficient numbers to satisfy the demand. In order to satisfy this demand, various distributing agencies import films from the United States and, in payment, have to tender dollars. They may not have any dollars themselves, but dollars can be bought from some specialized foreign exchange dealer by payment of pounds sterling. There is an "exchange rate," which is simply the number of dollars obtainable for one pound sterling in the foreign exchange market. The foreign exchange dealer is also receiving demands from Americans who hold dollars, but want pounds to pay for goods or services they find it profitable to import from Britain.

If, at the rate of exchange then in force, the demand for pounds from holders of dollars should just equal the demand for dollars from holders of pounds, the rate of exchange will be stable. If, however, at that rate of exchange, British goods appear dear to Americans so that there is less demand for the goods and, therefore, less demand for pounds to pay for them, foreign exchange dealers would find themselves sold out of dollars and loaded up with pounds. In such circumstances, if the rate of exchange were free to fluctuate, fewer dollars would come to buy one pound. We can see this more closely, perhaps, if we suppose that butter is being exchanged for shoes and the owners of butter have become disinclined to take the shoes, while the owners of the shoes still want butter as much as before. The owners of the shoes, in that event, would have to accept fewer pounds of butter for a pair of shoes than they received before.

Stabilizing Exchange Rates

The possibility of fluctuation in the rate of exchange is not an attractive one. It introduces too many uncertainties into international trade, particularly in respect of contracts entered into for long periods ahead. This both discourages such trade and makes it more costly, since various kinds of insurance arrangements to cover possible losses arising from exchange fluctuations have to be entered into. To stabilize the exchange rates the governments of the various countries are generally prepared to enter into the operations on the foreign exchange market. Thus, if more dollars were being demanded by holders of pounds than were being supplied, the British Government would probably sell any holdings of dollars it had, or offer any gold it had, which would be equally acceptable. If it did not interfere at all, one pound would fetch fewer dollars and in order to import an American article costing, say, ten dollars it would be necessary to pay perhaps three pounds instead of two pounds ten shillings. A point might be reached, however, when the British Government no longer has dollars or gold available to maintain the exchange rate. Various courses might then be taken if it were still desired to maintain it. If we could possibly push our wares, we might stimulate the demand for pounds to pay for them and so correct the situation

which has arisen. If this were not possible, it might be necessary for the British Government or various British concerns to raise loans of dollars from the United States Government or United States concerns. Such a method would put Britain under an additional obligation of paying interest on the loan, which would be an additional demand for dollars in future years. There would also be the alternative of rationing the dollars which became available to Britishers. In that case all dollars earned by exporting British goods would have to be paid into some central government-controlled pool, from which allocations would have to be made to those requiring dollars to pay for imports. In that way the excessive demand for dollars at the existing exchange rate, would be prevented from inflating the value of the dollar in terms of pounds. Tariffs and quotas have also been used for similar purposes since they, too, discourage the purchase of imports and thus help to lessen the demand for foreign currency.

The Parallel Between the State and The Individual

When we were discussing public finance—the Government's income and expenditure — we observed several respects in which public finance differed from private finance. The chief difference, the absence of an overriding necessity to keep the Government's expenditure within the bounds of its income, arose from the fact that the Government itself has control over the supply of pounds. When we consider the international sphere, we see that the Government of one country is not in a position to control the supply of foreign currency. Here then the parallel with an individual person who must keep his outgoings within the limits of his income, can be legitimately drawn. In the same way no country, Government, commercial concerns and individuals taken together, can afford to spend more foreign exchange than it receives. It may borrow to meet any excess spending, but very similar rules of prudence govern such borrowing as govern borrowing by individuals. It should be undertaken only to meet temporary conditions, or to enable such development to be be carried out as will at least pay the interest charges and probably also permit of some capital repayment. In the latter case the loan should be made for a term of a good many years.

Apart from borrowing or living off past accumulations, the only alternatives to adopt in face of difficulty in balancing the income and expenditure account are either to increase one's earnings of foreign exchange by exporting more, or to reduce one's expenditure of foreign exchange by importing less. Exporting more includes, not only sending goods abroad, but performing services, such as insurance or air transport, or catering for tourists, etc. for all of which foreigners require to make the home country a payment.

There may be one country, let us call it A, whose goods and services are demanded by other countries, which we will group together and call B, to a far greater extent than A is inclined to counterbalance with purchases from B. A must realize that B cannot fulfil their wish to avail themselves of A's goods and services beyond the extent to which A has provided

them with its currency by accepting their goods, etc. A's disinclination to accept B's produce must give way if it hopes to continue selling to B. The onus of correcting the maladjustment of the foreign exchange position lies as much, if not more, with those countries whose incomes exceed their expenditure as with those of whom the reverse is true. In the long run, indeed, it is more in their interest to do so; for if those whose expenditure exceeds income are obliged to correct the position, they can only do it by reducing their purchases, that is, by contracting world trade. But if the other countries correct it, they will do it by increasing their purchases, that is, by expanding world trade.

When we were discussing the furtherance of economic welfare by full employment, we said that an excess of exports over imports contributed to full employment. It is clear, however, that if one country has such an excess, some other country must have an excess of imports over exports. If the first country will not reduce its excess of exports by importing more, the second country may feel obliged to reduce its imports, especially if unemployment is a serious problem in the latter country. In other words, it will have to buy only what it can afford.

More About Money

At the beginning of this article we spoke of the fundamental position occupied in modern economics by money. Money was referred to when we said that the Government was not subject to the necessity which besets an individual of keeping expenditure within the bounds of income. It cropped up again when we said that it is possible for the Government to ensure that money is available for borrowing by industrial concerns needing the money to finance some expansion. What really is the structure of the banking system (see Fig. 1) through which money becomes available to the community? We have first the Bank of England, and secondly, the joint stock banks, the chief of which are Barclays, Lloyds, Midland, National Provincial, and Westminster.

We count as money the paper notes and the coins, and also entries in bank books not covered in full by such notes and coins, which we call credit. How is it that these tokens which, in themselves, are worth only a fraction of the value they stand for, are accepted as representing those actual values? Each of us accepts a one pound note knowing it to be only a piece of paper, because we know that everyone will accept it as being worth one pound when we wish to spend it. There is a confidence in the country-wide acceptance of such notes and bank entries, which itself makes them acceptable. In part, this is a feature inherited from the days when the note or the bank entry could be changed into a guaranteed quantity of gold, a commodity prized the world over. That cannot be done now, but the confidence which grew up in those times has been carried forward to the present day. There is another feature strengthening acceptance of these tokens. Almost everyone is under certain financial obligations to the Government—such as the payment of income tax. There is no escaping those obligaations, but they can be discharged by payment with notes or out of a

bank account. The ultimate use of money is this discharge of obligations to the Government (see Fig. 1). That fact, and the growth of general confidence in the willingness of everyone to accept such money, give money its value.

The Banking System

Whenever the Government makes a payment, say to an industrial firm for work done, the firm is able to present a cheque at the joint stock bank where it has an account. The appropriate amount of money is entered in the firm's account and the liabilities of the bank in question are increased, since it is liable to be called upon to pay out so much more cash. In order to balance this increase of liabilities, the joint stock bank in its turn presents the cheque to the Bank of England, where the Government keeps its account, as do all the joint stock banks. The joint stock bank's account at the Bank of England is credited with the amount involved, and in that way its assets remain in line with its liabilities. The Government's account at the Bank of England is, of course, reduced by the amount and the transaction is complete (see Tables A and B, on pages 364 and 365).

Now each joint stock bank has deposits belonging to such firms as the one mentioned above, and each has cash either in the form of notes and coin, or of an account at the Bank of England. The magnitude of the deposits compared with cash is always something like ten to one, however. There is no particular magic about this figure—banking practice over many decades has happened to establish that ratio. The idea behind it is that not all the depositors are likely to ask for notes and coin at the same time, and the banks are quite safe in allowing deposits to exceed cash in this way. In the example given above, the joint stock bank's deposits and cash are increased by the same amount, thus disturbing the ratio. This can be seen from an exaggerated set of figures. If we start with one and ten, they are obviously in the ratio of one to ten. If we add one to each of these, we have two and eleven, which are in the same ratio as one to five and a half. Thus, the ratio has been disturbed by the equal additions to both sides. The ratio can be restored either by an increase in the larger figure, which is "deposits," or by a reduction in the smaller figure, which is "cash." In other words, as a result of the transaction which we described, the bank may lend to more would-be borrowers—it may increase the total volume of credit—simply because, at the beginning of the process, the expenditure of some money by the Government merely increased the "cash base" of the bank (see Table C, pages 364-365). The other alternative must not be forgotten—the ratio of cash to deposits may be brought back to normal by reducing the cash. One way in which this may be done is for the bank to buy government securities. In that case, its assets remain the same, for the securities replace the cash, which is transferred from the bank's account at the Bank of England to the Government's account (see Table D, pages 364-365). Although the bank's assets remain the same, its cash has diminished from the high level to which it was temporarily swollen and it is, therefore, unable to increase its advances to clients.

If the Government wishes to increase the cash in the hands of the joint stock banks so that they may be well placed for making advances to borrowers, the easiest course is for it to have its account at the Bank of England credited with an appropriate amount, and then to disburse that credit by expenditure which will find its way into the accounts of the joint stock banks in a manner similar to that described in the transaction referred to in the table below. To balance the increase in the liabilities of the Bank of England caused by the increase in the Government's deposit there, a like amount is written on the assets side under the heading "Government Securities." This revelation of the method of operation of public finance to persons very much limited in what they can do by the size of their weekly pay packet, is apt to provoke in them either the feeling that the explanation is entirely wrong (though where, they may not be able to tell) or the belief that the Government can finance itself entirely in this way without any recourse to taxation. Nevertheless, the explanation is, though simplified, a correct one. The reason why the Government cannot

TABLES ILLUSTRATING WHAT MAY HAP-

BANK OF ENGLAND

A

Liabilities		Assets	
Deposits of Joint Stock Banks	100	Notes and coin . . .	5
Deposits of Government .	10	Government Securities . .	105
	110		110

B

After the Government has presented a cheque for "1" to the firm, the firm ha

Deposits of Joint Stock Banks	101	Notes and coin . . .	5
Deposits of Government .	9	Government Securities . .	105
	110		110

Government's deposit is reduced by 1 and deposits of Joint Stock Banks increased by 1

C

This enables the Joint Stock Banks to increase their advances to the public and each

Deposits of Joint Stock Banks	101	Notes and coin . . .	5
Deposits of Government . .	9	Government Securities . .	105
	110		110

D

Or the Joint Stock Banks might increase

Deposits of Joint Stock Banks	100·1	Notes and coin	5
Deposits of Government . .	9·9	Government Securities . .	105
	110		110

Government account is increased by ·9 and Joint Stock Banks' account decreased by ·9.

carry out its expenditure without taxation is that it must have one eye on prices of all goods and services. Roughly, it can be said that it is nowadays recognized that the Government must leave just sufficient purchasing power in the hands of the public to ensure full employment, but not so much as to cause appreciable price rises.

Now our earlier references to money can be more fully understood, particularly the method by which the Government can ensure that banks are in a position to make loans. Fig. 1 shows how money is put into circulation by the operation of the banking system, government expenditure and industrial investment and how it finally returns to the source again by the channels of taxation and savings.

Relation of Economics to Current Problems

Our discussion of economics in theory and practice has covered many of the most fundamental matters with which the subject deals. These matters have, however, been treated as though they were in a water-tight compartment unaffected by other aspects of human activity. This was essential

PEN WHEN THE GOVERNMENT SPENDS

JOINT STOCK BANKS

A

Liabilities		Assets	
Deposits of Public	250	Notes and coin plus Banks' deposit at B. of E.	25
		Government Securities	125
		Advances to public	100
	250		250

Ratio cash to deposits 25 : 250 or 1: 10.

B

paid it into its bank and the bank has paid it in at the Bank of England:—

Deposits of public	251	Notes, etc.	26
		Government Securities	125
		Advances to public	100
	251		251

Ratio cash to deposits 26 : 251 or 1 : 9·65.

C

advance creates an equal deposit for the person to whom the advance is made:—

Deposits of public	260	Notes, etc.	26
		Government Securities	125
		Advances to public	109
	260		260

Ratio cash to deposits 26 : 260 or 1: 10.

D

their holding of Government Securities:—

Deposits of public	251	Notes, etc.	25·1
		Government Securities	125·9
		Advances to public	100
	251		251

Ratio cash to deposits 25·1 : 251 or 1: 10.

in order to get any understanding of the economic field at all. It is now necessary to remove some of this artificiality, and obtain a glimpse of the relationship of economic matters to other matters, since economics is part of the much larger study of human welfare in general. All that has been said has been said from one point of view alone, namely the need for maximizing economic welfare. Human welfare, however, is also conditioned by other considerations; for example, by social, political, moral, spiritual and æsthetic factors amongst others. Not that these are all independent spheres; the activities falling within one sphere influence those in other spheres. Certain schools of thought believe that one or other of the spheres is the dominant one, so that the remainder are entirely conditioned by the one. Thus, our moral standards might be entirely determined by our economic system; alternatively, our moral standards might themselves determine the nature of the economic system. No attempt is made here to state which—if either—of these alternatives is true. The problem is simply posed in order to be sure that the reader is not left with the impression that economics covers the whole of the study of human society.

Examples of Interaction

Some of the ways in which economics comes in contact with other spheres may be mentioned here. Æsthetics, or the study of beauty, is a case in point. Often the cheapest way of arranging anything, the way involving the least expenditure of time and resources, is not the most beautiful. Thus considerations of town and country planning may clash with purely economic considerations. The economically most suitable place for mining a certain mineral might be in some area renowned for its natural beauty, whose perfection would be marred or perhaps even destroyed by industrial development. Should economic welfare or cultural welfare be the deciding factor? It should not be imagined that because the two considerations sometimes clash, they need necessarily do so. In fact, we might often have fared better in the past if we had understood the extent to which sound economics and good taste coincide.

In our study of unemployment we saw how an increase in the mobility of labour would make the attainment and maintenance of full employment easier. Economic welfare demands full employment, and as the Government has agreed that it has the general responsibility for securing that state of affairs, it would be very tempting to conclude that the Government should fulfil its responsibility by compulsory movement of labour. It could certainly claim that it was serving the needs of economic welfare. But social considerations, which demand respect for certain freedoms of the individual, point against such a policy. Does one of these considerations outweigh the other, and what circumstances determine their relative importance?

Many regret that the increase in mechanization, which serves economic welfare by maximizing the national income, is more and more tending to reduce workers themselves almost to pieces of machinery. Skilled craftsmanship, it is held, is disappearing. Is this desirable?

These are questions to which our times demand an answer, and our

society is always giving answers to such questions, even though it does not do so consciously. The Industrial Revolution decided in favour of towns which were cheap to the employers of the day and against social and æsthetic considerations, even against the long view economic advantage of the whole community. Similar decisions are being made today, and we should have our eyes open to their implications. That demands an understanding of the working of our economic system.

Even within the purely economic sphere there are currents of development which could be shifted one way or the other by expression of the public will through our political machinery. In many industries technical developments have resulted in larger and larger plants becoming the cheapest to operate. This has had the effect of reducing the number of firms comprised in any particular industry, and consequently in reducing competition (see Fig. 13). The question arises, whether or not it is desirable that these monopolies should continue to be conducted in the interest of the private director and shareholder, or whether they should in future be controlled in the interest of the general public.

Influence of the Individual

We are gradually devoting more and more of our time and resources to the provision of goods and services which can only be effectively provided in response to expenditure by the Government. Education and health services are examples. The proportions of our time and resources which are being employed as a result of expenditure by individuals is diminishing. In other words, there is a communal choice and a private choice. The private person can exercise his influence over it and benefit, even though it is a communal choice.

Then there are such matters as the choice we can make communally between the various proportions of our national income that shall be devoted to current consumption and to the building up of our capital equipment; the methods by which incentive to effort can be maintained if more equal distribution of incomes is attempted; the possibility that the whole of the personnel of an industry—employers and workers together might take action which would be inimical to the interests of the whole community; and so on.

Economics and Citizenship

All the examples which have been quoted are matters which our ever-developing economic situation is presenting for decision to our generation. They and others, especially one which has presented itself for long, namely the question of public versus private ownership of resources, occupy the stage. No attempt has been made to settle these matters, but some of the elements of economics here presented should enable the reader himself to apply sound economic reasoning to the practical situations which daily confront him.

We said at the beginning of this chapter that all the matters with which economics deals affect closely the health, comfort and happiness of everyone. An understanding of the subject is, plainly, essential to all who intend to fulfil their obligations as citizens and who desire to use intelligently all their influence to improve the common lot.

CHAPTER 10

DISCOVERIES AND INVENTIONS

The debt we owe to the Victorians. The achievement of flight. Jet propelled aircraft. Aircraft instruments. Radar. Wireless telegraphy and telephony. Direction-finding and beam transmission. Broadcasting. Principles of television. The cinematograph. Sound films and colour films. Nature and applications of X-rays. Discovery of radium. Radium and medicine. H.11. Insulin. Vitamins. Dried blood. The iron lung. Mepacrine. D.D.T. Penicillin. The sulphonamides. Surgery. Miscellaneous discoveries and inventions in industry. Metallurgy. The cyclotron. The atomic bomb.

BECAUSE we see most clearly that which is nearest to us, we are apt to consider the twentieth century, although half of it is unexpired, as the most wonderful period of progress in all Man's long history. Certainly the last half-century has been prolific, both in inventions and in discoveries. Man was born in chains, the bondage of ignorance, poverty, disease and dirt; but everywhere today science is setting him free. For good or ill the twentieth century has brought us Einstein, radium, wireless, television, radar, the talkies, rationalized production, Spitfires and freight planes, the *Queen Elizabeth* and the high-powered motor boat, synthetic oil, rubber and vitamins, plastics, rocket shells, atomic energy, penicillin, the transmutation of the elements, X-ray analysis, and other things too numerous to mention.

In every sphere of activity the natural progress of the years has been speeded up by the fierce urge of two world wars, which caused money to be spent on research upon a scale never before dreamed of; things have been done which would have been called the dreams of a visionary when King Edward VII came to the throne.

Fuller inquiry, however, will show us that very few indeed of these marvels are absolutely and completely the product of the last two generations; and although we are rather too apt to sneer at the prim and staid mid-Victorians, we should do well to imitate their thoroughness at the expense of some of our own more superficial ways. The Victorians, too, might well have claimed that their own age was one of the most remarkable in history. Did it not produce Faraday, the electric motor, electric light and power, the telephone and telegraph, locomotives, Darwinism, internal combustion engines, and a host of other things which are the foundations of what has been discovered since? While keeping our minds as much as possible on the present, therefore, let us not forget the very great debt which we all owe to the past.

Every discovery and invention has a long ancestry, the right idea growing as it were out of other people's failures. It is also true, unfortunately, that if a discovery is not announced at the right time

—unless, that is, the world is in the state of mind to receive it—the discovery runs a great risk of being smothered by ridicule or neglect. Darwin would have been burnt at the stake if he had published *The Origin of Species* two centuries earlier; Galileo in fact narrowly escaped that fate, and Bruno was actually burnt to death for asserting that the Earth moved round the Sun.

The Victorians were no better than their forbears. When Newlands propounded the Periodic Law—an arrangement of the elements which lies at the very basis of chemistry—the assembled chemists of England laughed him out of the hall. People are living who can remember how Pasteur was derided, decried and persecuted. For years, too, Lister's antiseptic surgery was frowned upon and mocked.

Remembering this complicated historical background, let us now glance at a few outstanding achievements of our own time.

Conquest of the Air

The twentieth century will always mark an epoch, because at its very dawn men succeeded in realizing the boldest of their dreams, flying by means of heavier-than-air machines. This achievement is beyond question the most important invention of modern times. It has altered the balance of power between nations great and small, has drastically modified previous ideas of warship construction, has made a thousand-mile journey a matter of a mere three hours, and has destroyed all the natural frontiers between peoples. By its aid the vast German empire of 1940–43 was built, and by the same power it was destroyed in an even shorter period. Men have flown at more than ten miles per minute, or faster than any bird; they have climbed in a heavier-than-air machine to more than 56,000 feet, or twice as high as any bird; and they have kept aloft for many days on end. All this became possible because two young brothers decided that to attempt to imitate birds was not the right approach to the problem of flight, and set about solving it in a different way.

The Wright Brothers

The two brothers Wilbur (1867-1912) and Orville Wright (1871-19—) were the sons of an American clergyman who lived at Dayton, Ohio, and their enthusiasm was aroused by Lilienthal's work in connexion with gliders. They also saw that the first problem of flight was how to control a machine in the air, a matter only to be learned by gliding. When they had found the right kind of glider, they proposed to put a motor into it. This was the correct approach, but with one qualification that afterwards cost many lives: the essence of the Wright machines was that the pilot positively controlled his machine by his actions; and numerous known devices for making a machine inherently stable or foolproof were intentionally left out. The pilot's safety must depend on his own skill; he really had to be a "flying man."

The Wright machines were biplanes (see Fig. 1). To obtain lateral control, the brothers invented wings in which both ends of the upper and lower planes could be warped, so that when the ends on one side were raised those on the other side were lowered. Thus if one

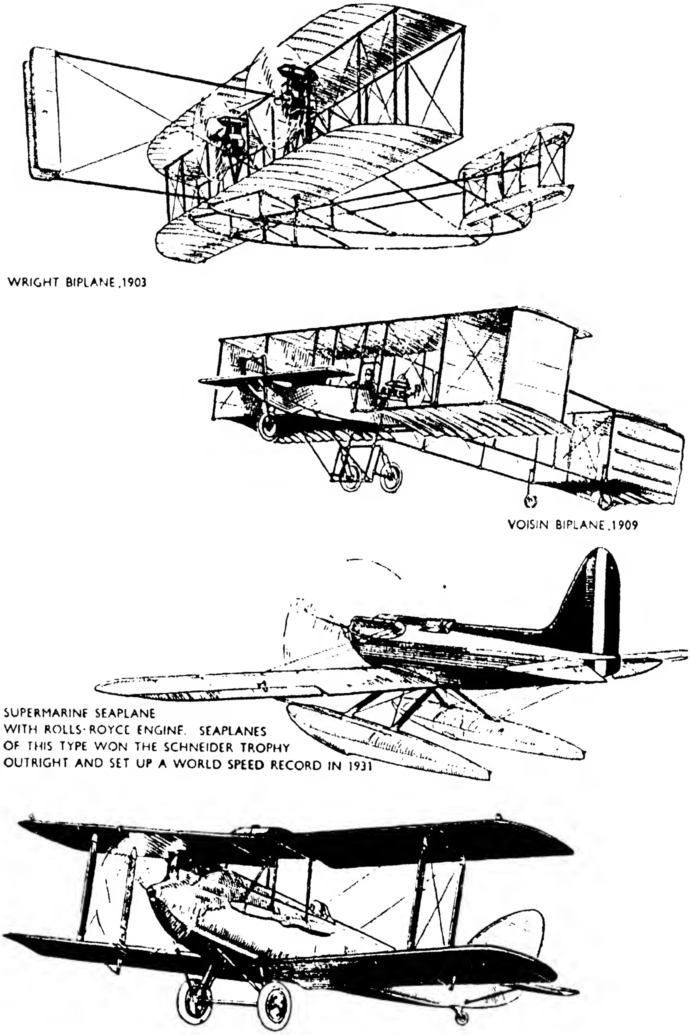
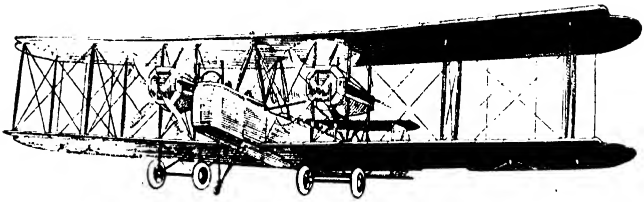
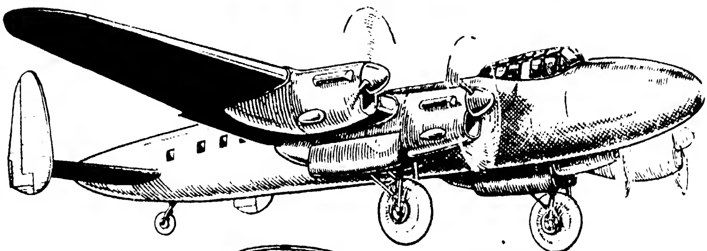


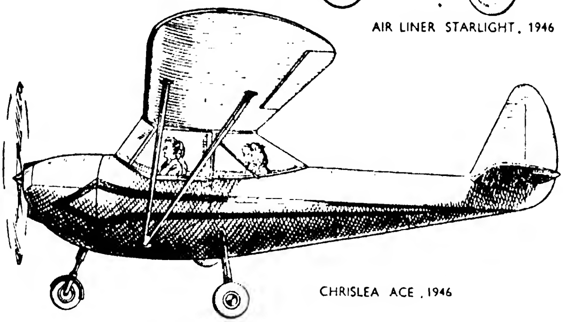
Fig. 1. *Aircraft types which record the progress in design during less than fifty years of flying in heavier-than-air machines. The constant demand for*



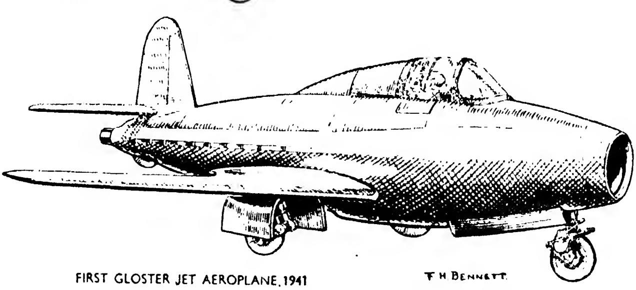
VICKERS VIMY BIPLANE, 1919



AIR LINER STARLIGHT, 1946



CHRISLEA ACE, 1946



FIRST GLOSTER JET AEROPLANE, 1941

greater speed has directed ever-growing attention to streamlined design, more powerful multi-cylinder piston engines, and jet propulsion units.

pair of wings dropped suddenly in an air pocket (or the machine, in technical parlance, side-slipped), their extremities were lowered, so as to increase the lift, whereas the opposite wing-tips were raised, thus helping the machine to regain stability. The first Wright glider, completed in 1900, was tested on the lonely seashore near Kitty Hawk, North Carolina; it had a wing span of 165 feet. The brothers soon found that much more study was necessary. They made actual measurements of the lift and drift under various loads. For additional control, they built a horizontal elevator plane in front of the main wings. The pilot lay prone on the wing, so as to reduce the resistance. At Dayton no fewer than two hundred models were built, most of which were tested in a wind tunnel; this being the first notable use of that invaluable device which now plays such an essential part in aeronautical research. The third man-carrying glider appeared in 1902. They had so much faith in it that on its basis they designed the first Wright aeroplane.

First Successful Flight

The Wrights' first power-driven aircraft had a wing-span of 40 feet, the wings measuring six and a half feet across; the total wing area was 510 square feet. As the total load, including the pilot, was 1,000 lb., each square foot of wing had to provide two pounds of lift. (A modern Spitfire has a wing load of 26 lb. or more per square foot, while the new Avro Tudor (see Fig. 3) has a wing load of 53½ lb. per square foot.) Power was provided by an ordinary four-cylinder water-cooled motor-car engine, cut down as much as possible to save weight; it developed twelve horse-power at nine hundred revolutions per minute. There was a chain drive to two propellers mounted behind the main planes and driven in opposite directions. The pilot lay prone on the lower wing, operating his warping control by means of a cradle attached to his hips. His hand clutched a small lever attached to a rotating bar in front of him, which moved the elevator plane up or down at will. In order to provide an easier take-off, the machine ran upon a monorail for a short distance.

On the morning of December 17, 1903, in the presence of five witnesses, Orville Wright mounted this machine at Kitty Hawk sands. The engine was started. After running for about forty feet along the monerail, the Flyer rose from the ground to a height of eight to ten feet, where the pilot deliberately kept it; and it flew against a sea wind of twenty to twenty-five miles per hour for twelve seconds, when it landed safely. Three more flights were made that morning, the last one covering 852 feet in fifty-nine seconds. The air-speed of the machine was about thirty miles per hour.

For good or ill, Man had solved the problem of flight; but the Wright brothers met with the usual fate of inventors of great new things: nobody believed them. As, moreover, they naturally kept their experiments secret, many Europeans continued for years to disbelieve. Meanwhile, in November, 1904, Wilbur Wright flew four times round an eighty-acre field near Dayton, in five minutes four seconds. The Wright planes were steadily improved, and in a flight in October, 1905, they covered 20¾ miles at

thirty miles per hour. Up to this time nobody else in the world had flown an aeroplane; nevertheless, the United States War Department took two years before deciding to order one.

There is not space in this chapter to describe the progress in design since 1905; nor is there space to give an account of the developments which have given us the giant military and commercial aircraft of today. Some idea of this can, however, be seen in Figs. 1, 3 and 6. All types of aircraft in the future are likely to be somewhat different from any of the types which exist today, and the modern tendency seems to point to more widespread use of jet propulsion.

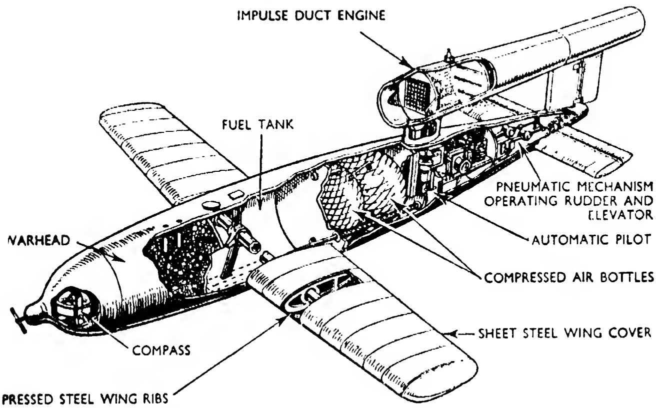


Fig. 2. *V-1 flying bomb in part-section. Direction and range were controlled by an automatic pilot and a revolution-counting propeller device.*

Jet Propulsion

The words "jet propulsion" will for a long time to come recall the noisy and nerve-shattering German V-1s or doodle-bugs. These flying bombs were very much like small aircraft (see Fig. 2). Actually they were pilotless aerial torpedoes, with wings, jet propulsion, and a speed of 350 to 400 miles per hour. They carried a ton of explosive in the warhead and exploded on impact. The second V-weapon, however, the rocket bomb (Fig. 4), had no relation to aircraft, being in many respects very much like a torpedo, and was far more ingenious and deadly than the flying bomb. The rocket bomb was forty-five feet long, five and a half feet in diameter, and was shaped like a huge cigar. At the head was two thousand pounds of explosive. Behind it was the controlling mechanism and radio control, and behind that lay two large tanks, one holding 7,500 gallons of alcohol and the other five tons of liquid oxygen. A turbine in the rear drove a pump which forced the alcohol and oxygen through jets into the combustion chamber. There they were electrically ignited, the gas being forced out at the rear of the chamber so violently as to give an upward thrust of about

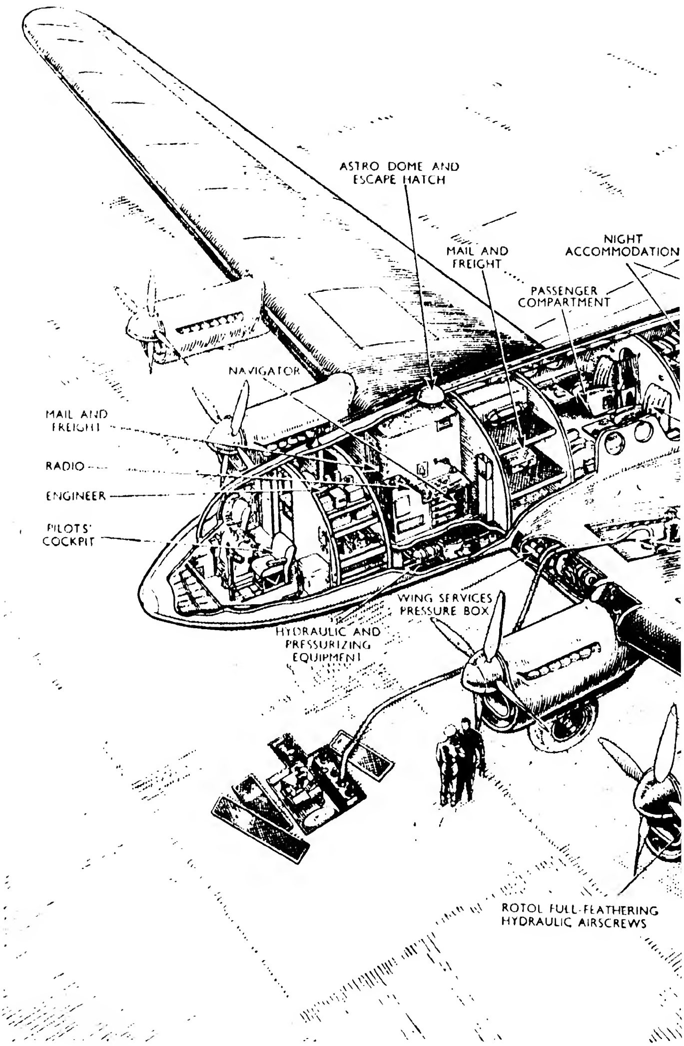
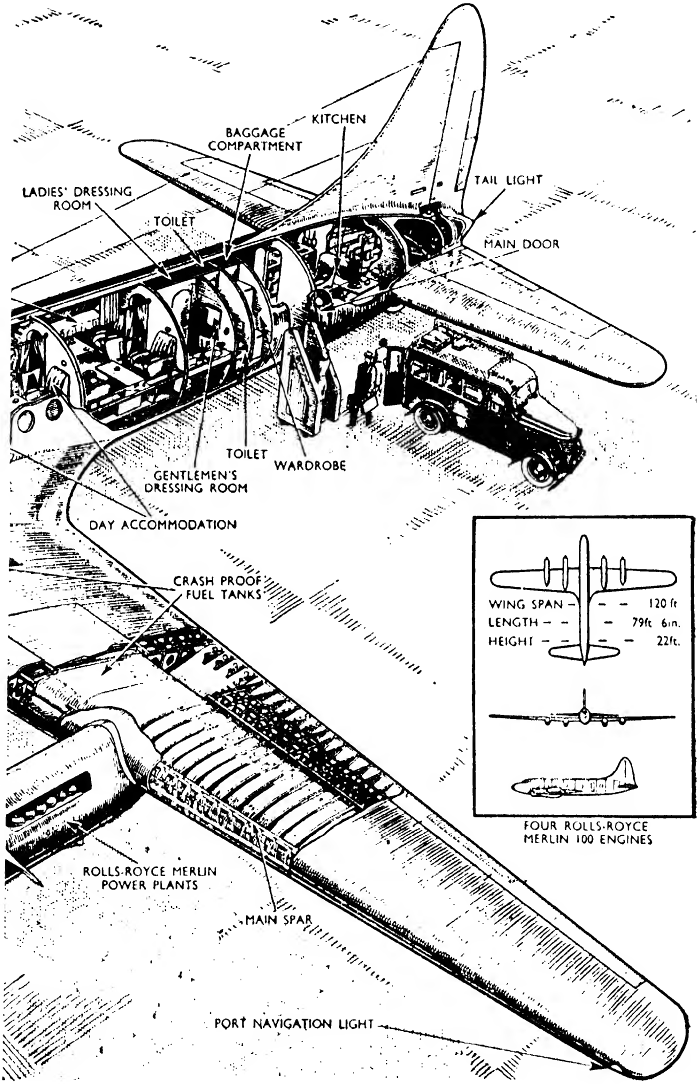
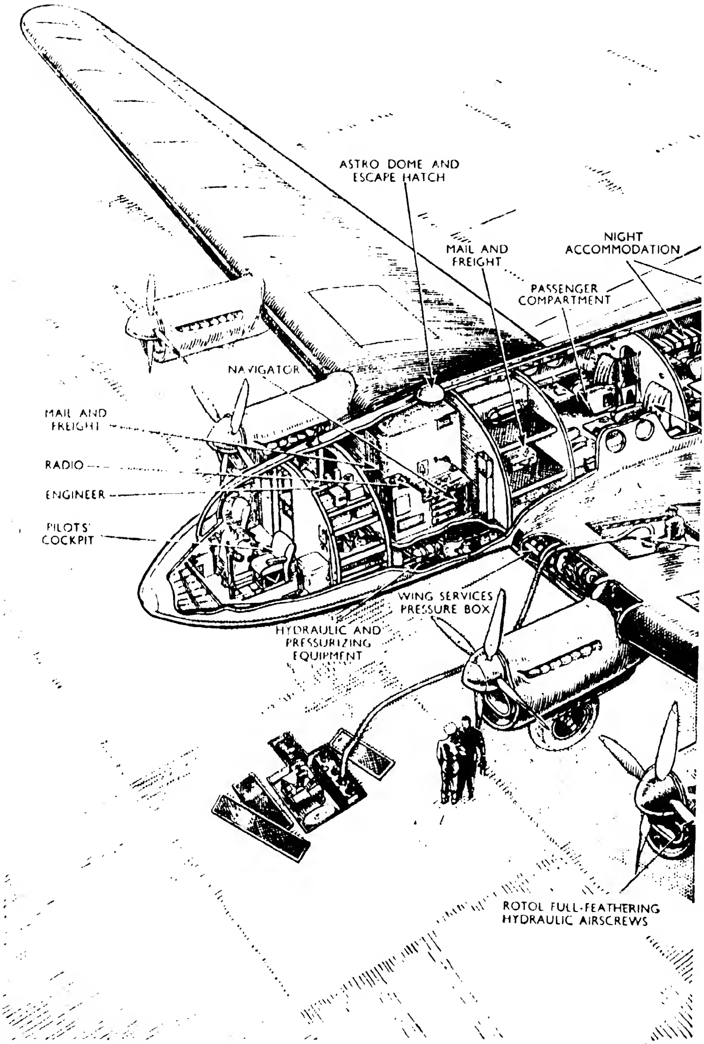


Fig. 3. *Prototype of the Avro Tudor I in part section, from a drawing reproduced in " Flight." Four Rolls-Royce engines give this luxury passenger*



aircraft a cruising speed of 300 m.p.h. at 22,500 ft. Fully laden it has a range of over 4,000 miles. The prototype was the first British post-war airliner to fly.



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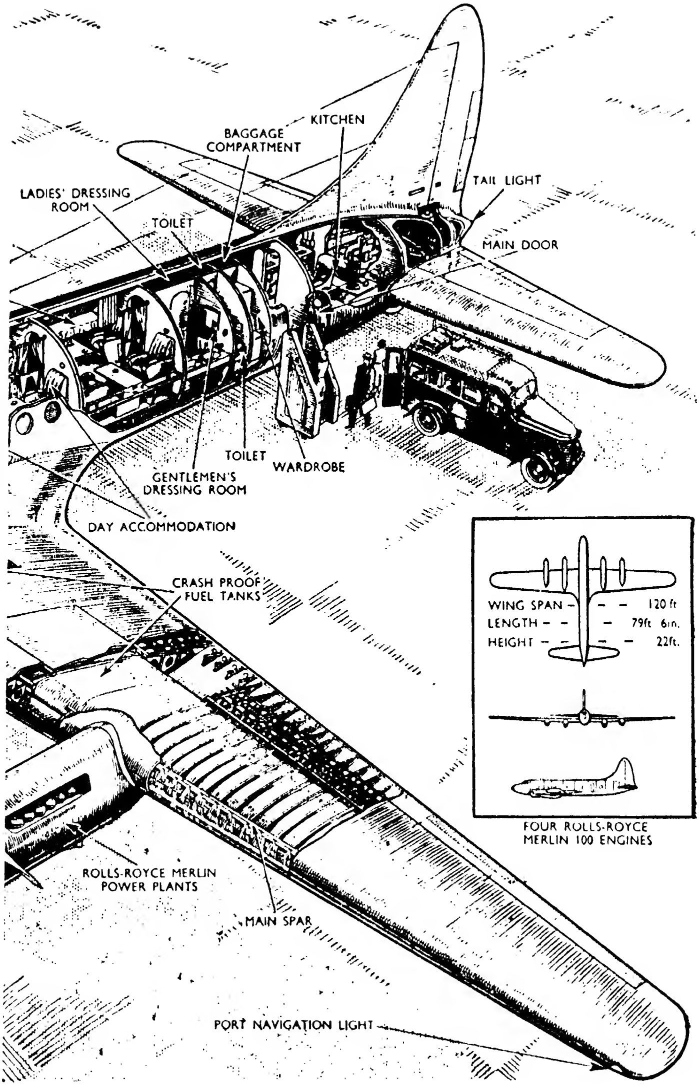


aircraft a cruising speed of 300 m.p.h. at 22,500 ft. Fully laden it has a range of over 4,000 miles. The prototype was the first British post-war airliner to fly.

twenty-six tons. The rocket bomb was fired vertically; but after a short time a gyroscope brought its four controlling vanes into play and it curved away like an ordinary shell towards its target, the fuel supply then being automatically cut off.

Neither the flying bomb nor the rocket bomb should be confused with jet-propelled aircraft. The idea, which was quite an old one, was taken up by Group Captain (now Air Commodore) Frank Whittle, who patented his plan in 1930. Eventually a company (Power Jets, Ltd.) was formed to exploit the invention, and after four years' work the first jet engine ran successfully in 1937. In that year the Air Ministry placed a contract for a jet-propelled aircraft, and this machine (see Fig. 1) was successfully flown in May, 1941.

Aircraft Instruments

The instrument panel on a modern aircraft is a truly imposing sight. Many of the instruments are

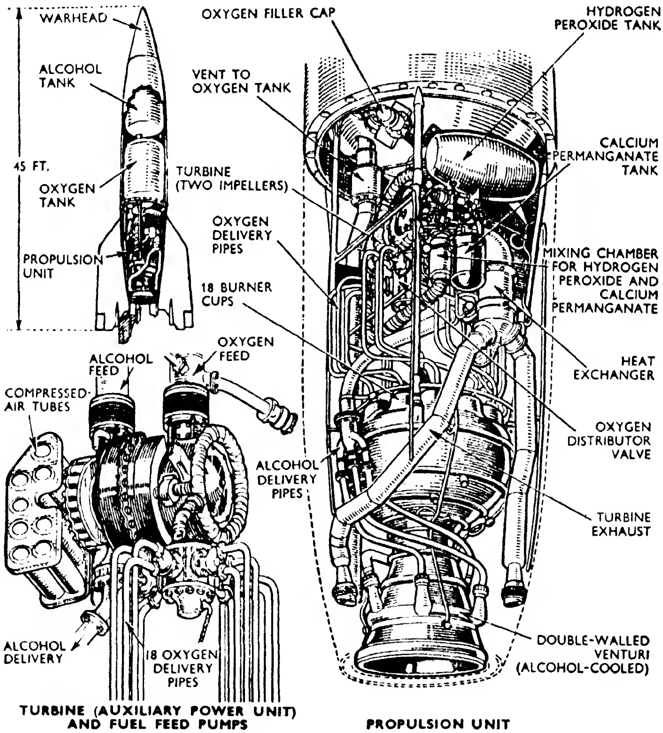


Fig. 4. *Part-section drawing with views of the auxiliary power and propulsion units, showing the constructional details of a V-2 rocket bomb.*

connected with the engines, recording the oil pressure, air pressure, fuel pressure, etc., all of which the pilot must have in mind, though not necessarily always under his eye. Then he has an airspeed indicator (see Fig. 5), which registers the difference of pressure between still air and the higher pressure due to the aircraft's speed (translated into miles per hour). The aircraft's altimeter is essentially an aneroid barometer; as the plane climbs the altimeter registers the falling atmospheric pressure on a dial, in terms of thousands of feet. The rate-of-climb indicator contains a chamber which air can leave or enter only very slowly. When the plane climbs, the outside air pressure drops more quickly than the pressure within the chamber; when descending, the outside pressure rises above the inside pressure. The difference between outside and inside pressure is shown on a dial as hundreds of feet per minute up or down.

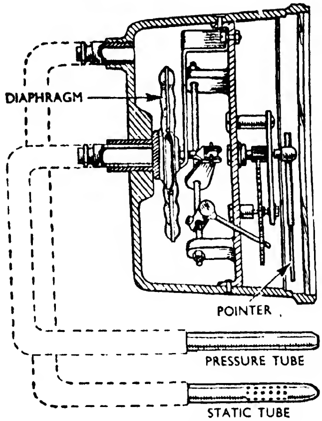


Fig. 5. *Airspeed indicator. As speed increases the air pressure rises in the pressure tube, and the diaphragm expands, moving the pointer.*

A special and very ingenious instrument, evolved for warplanes but capable of general use, is the gen box, familiarly known as "Mickey." Built into the fuselage, it sends down to the ground a succession of electrical impulses; their echo or "bounce-back" is interpreted by the instrument in such a way as to build up a sort of contour map of the ground surface which enables the pilot to form some idea of his whereabouts, even though everything be shrouded in fog. Another valuable invention is the distant reading compass, a remarkable instrument that gives accurate readings where the old types of compass would be useless through the aircraft suddenly changing course, or banking, or being violently shaken. The distant reading compass comprises a special gyroscope, mounted above a magnetic compass, each affecting the other; they compose a master unit, which is mounted as far as possible from magnetic interference, and usually in the tail of the aircraft. Subsidiary compass units (repeater compasses), mounted beside the pilot, navigator and air gunners, are wired to the master unit and repeat its movements. The master unit is not affected by gunfire, sudden violent changes of speed, or nearness to the magnetic poles. It even has a connexion which enables the difference between magnetic and geographical north to be adjusted automatically; and the instrument can be made to operate the "automatic pilot."

Most planes are fitted with an artificial horizon, controlled by a gyroscope; it shows the position of a small model aeroplane relative to

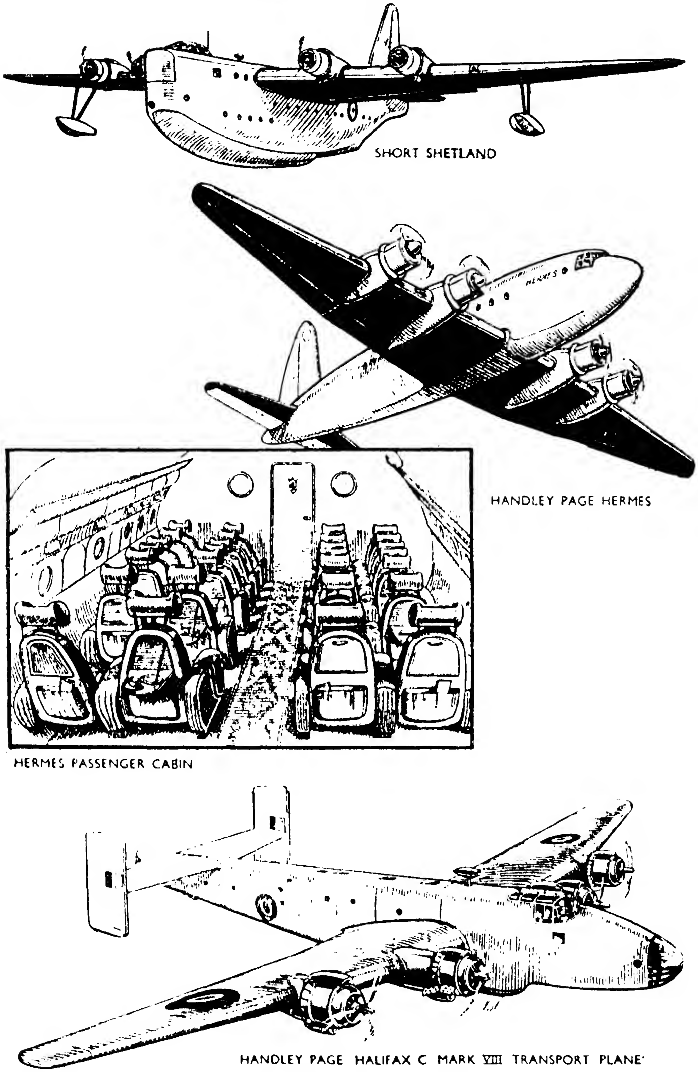
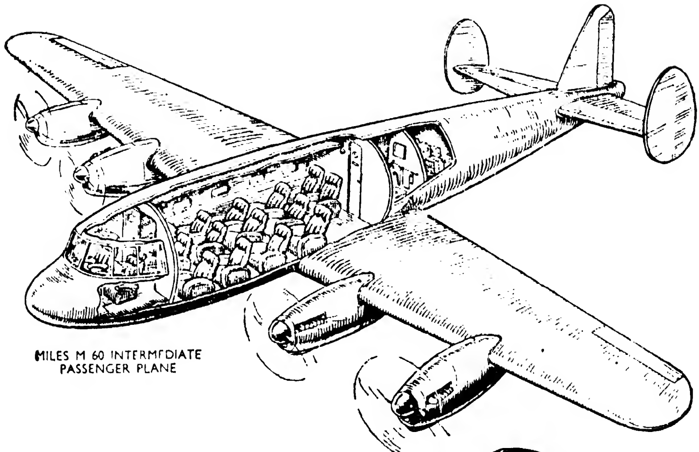
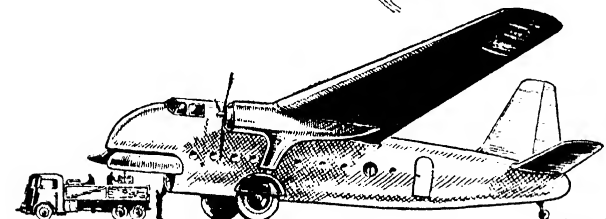


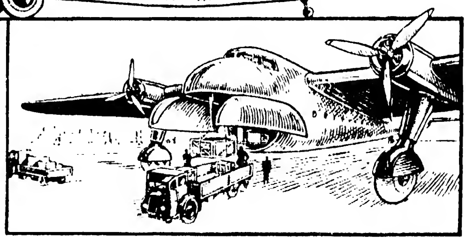
Fig. 6. *Some typical examples of commercial passenger and freighter aircraft. Note the inset of the Handley Page " Hermes " fuselage which shows the luxurious passenger compartment. The inset of the Bristol "Freighter "*

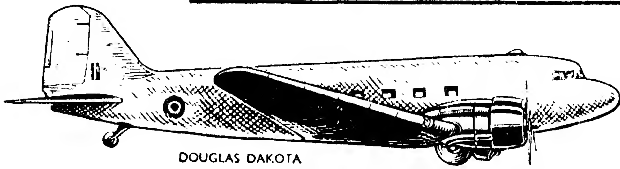


MILES M 60 INTERMEDIATE PASSENGER PLANE



BRISTOL FREIGHTER AIRCRAFT (ABOVE) WITH DETAILS OF NOSE LOADING HATCH (RIGHT)





DOUGLAS DAKOTA

shows how freight is loaded and stored for a long-range flight. A feature of modern aeroplane design is the attention that is now paid to the crew's quarters —this is illustrated (above) in the Miles M60 intermediate passenger plane.

the horizon marked on the instrument, and enables the pilot to see the altitude of his machine at a glance. "George," the famous automatic pilot (see Fig. 7), is an artificial horizon combined with a directional gyroscope. It makes it possible for the pilot to fly without seeing where he is going and yet to know the altitude of his plane at any moment; "George" also automatically moves the controls and so corrects the plane when necessary. The wireless set, of course, is most important to the pilot; for (except on some war operation where wireless silence is essential) he is in constant touch by radio with base.

Radar

One of the most far-reaching modern developments of wireless waves has been the growth of radio-location technique or radar. Like many other scientific discoveries, the principle of radar is extremely simple, but the construction of apparatus to make it effective has proved a matter of great difficulty, involving years of research by many people. The principle is simply this: very short-wave wireless impulses are directed as a concentrated beam in some particular direction, so as to cover or flood a given area of the sky. If an aircraft should enter this area many of the waves will be intercepted and reflected back to the transmitting station, as a so-called echo. The shorter the wave, the more effective is this result.

The distance of the aircraft can be determined by the nature of the echo itself, which also enables the plane to be identified, especially in wartime, as friend or foe, friendly aircraft being fitted with a device which enables the receiving station to distinguish them. By taking simultaneously two echoes of the same aircraft from different heights, it is also possible to deduce the approximate altitude of the machine by the difference between the strength of the two signals. Finally, by directing beams from two transmitting stations to a given area, when the machine enters that area its echo is received at the two stations almost simultaneously so that it can be triangulated in space. The radar receiver is a cathode-ray tube, on which a spot of light indicates the position of the object. By keeping the transmitter-receiver revolving horizontally through 360 degrees, and drawing on the screen of the cathode-ray tube a map of the surrounding country, the movements of the object can be observed continuously.

The principle of radar was known at least as far back as 1934, and by 1936 five stations had been erected on the British east coast. All the coasts facing Germany were fully equipped long before the outbreak of war: it has been officially disclosed that for months before September, 1939, no aircraft approaching England failed to be detected long before it reached the coast.

Two essential operations still had to be made possible, however: the identification of friend or foe, and the detection of small objects near the ground or at sea-level, such as the conning tower of a submarine. The first problem has been only partially solved by the means already referred to, but the second objective was fully achieved.

By the invention of the magnetron valve it became possible to send out waves of great energy but very small wave-length, only a few centimetres,

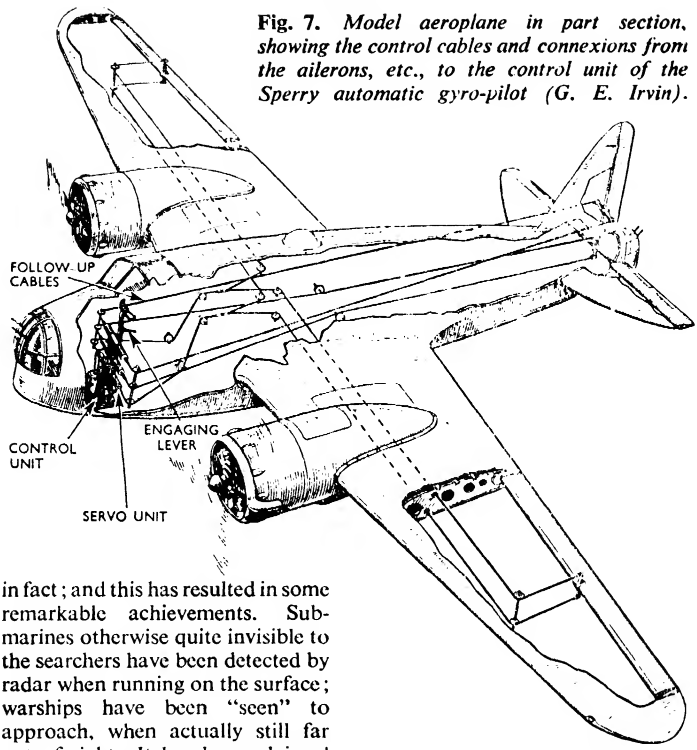


Fig. 7. *Model aeroplane in part section, showing the control cables and connexions from the ailerons, etc., to the control unit of the Sperry automatic gyro-pilot (G. E. Irvin).*

in fact; and this has resulted in some remarkable achievements. Submarines otherwise quite invisible to the searchers have been detected by radar when running on the surface; warships have been "seen" to approach, when actually still far out of sight. It has been claimed that the German battleship *Scharnhorst* was so detected, thus enabling H.M.S. *Duke of York* to range her and open fire before the Germans had any inkling of their danger. The accuracy of anti-aircraft gunfire against raiders and V-bombs was greatly improved by the use of radar. As a ranging device it has been installed in all the larger British ships of war; there are even small sets in numerous motor torpedo craft.

The ordinary merchantman, wallowing through the sea on some dark and foggy night, can determine his position by the use of radar, with an exactitude never before dreamed of; for of course, all the accumulated knowledge of wireless direction finding was at once applied to the new discovery. Finally, an airman flying in fog, cloud or darkness can, as already described, receive by means of his gen box a contour map of the ground beneath him.

Wireless Telegraphy

Another outstanding discovery of the twentieth century is wireless telegraphy and its offspring, broadcasting. Here again, however, the idea was far from new, for in 1842,

Samuel Morse, the inventor of the Morse code, sought a way of transmitting electrical impulses through water. He ran two wires along the ground parallel to one another, on either side of the Washington Canal, and earthed them by sinking copper plates in the water. As might be expected, he found that he could transmit messages from one wire through the water to the other wire.

Years afterwards this idea was reinvestigated and patented by J. B. Lindsay, of Dundee, and by the famous electrical engineer Sir W. H. Preece, of the British General Post Office. Preece conveyed messages across the Solent in this way in 1882. Meanwhile, Clark Maxwell had predicted that electromagnetic waves existed, of immensely greater length than the waves of ordinary light and would ultimately be discovered (1867). Such waves, which are the basis of modern wireless transmission, were in fact discovered by a young German, Heinrich Hertz, in 1887; he showed that as regards speed and other characteristics they behaved like waves of ordinary light. If an electric current, while passing along a line, had to jump a small gap a spark occurred, and this spark set up the electro-magnetic wave, a wave moreover the length of which might vary from a few metres to many miles. Some means for detecting the waves was needed, of course. Hertz used a simple coil of wire, the Hertz resonator; but in 1892, Edouard Branly invented a coherer, which consisted of a mass of loose metal filings in a glass tube plugged by two silver rods. Ordinarily such filings resist the passage of an electrical current, but when electro-magnetic waves reach them they become momentarily compressed or coherent (hence the name) and will permit the passage of a current. This principle, already discovered by D. E. Hughes independently, led eventually to the invention of the microphone. In this instrument the vibrations of a diaphragm responding to sound waves pressed on a core of powdered carbon; this caused intermittent electrical impulses to be transmitted along a wire to a distant receiver, where their effect on a small electro-magnet caused another iron diaphragm to vibrate in sympathy with the first one and so to reproduce the original sound.

Marconi

In a sense, Marconi's great career began in England, for his attention was attracted by Professor Righi to a lecture by Sir Oliver Lodge on coherers. Marconi, who was then only twenty-one years old (1895), made experiments at home. He had the idea of earthing one wire from the Hertz spark producer and attaching the other to a vertical aerial; this was his transmission set, and by a similar arrangement at the receiving end of a vertical aerial, and an earth contact connected to the coherer, he found it possible to transmit and receive messages over considerable distances.

Marconi came to England and on June 2, 1896, took out his first patent. Preece and the General Post Office were interested, facilities for experiments were given to the young Italian, and from that moment he never looked back. His success was partly due to his own genius and partly to the great enterprise of the Marconi Company in buying up every invention which

would facilitate their own operations. By September, 1897, Marconi passed recognizable signals from Salisbury to Bath, a distance of thirty-four miles; by 1899 his system was adopted for reporting the *Shamrock — Columbia* yacht race, and was also taken up by the British War Office for use during the Boer War. In 1900, wireless telegraphy had already saved lives at sea; sets had been installed on numerous warships, and the inventor, seizing fortune with both hands, began to build a high-power station at Poldhu, Cornwall, with the object of sending wireless messages across the Atlantic.

The masts at Poldhu were 210 feet high, and carried fan-shaped aerials. The aerial at the Newfoundland station, seventeen hundred miles away, was supported by a kite. In spite of wild weather, which made it difficult to keep the aerial up, the first transatlantic wireless signal was received at St. John's, Newfoundland, on December 12, 1901. It was not understood at first how the wireless waves adapted themselves to the Earth's curvature over such a vast distance; but the subsequent discovery of the Heaviside and Appleton layers in the upper atmosphere enabled the mystery to be explained: upon entering these layers the waves curled over, so that actually they were reflected back from space. (This reflection also explains the fact that within a certain distance of the transmitting aerial some waves cannot be detected at all.)

Marconi improved on the Branly coherer, by inventing a simple little instrument in which, by magnetic induction, the oscillations in the receiving aerial were converted into audible clicks in a telephone earpiece. Gradually, more facts were established about the new means of communication: the great range of available wavelengths, the nature of interference, atmospherics, the directive properties of wireless waves, and so on; but always the messages had to be sent by a spark from a powerful generator, so that the waves were broken or discontinuous. The use of wireless became obligatory on all large ships of practically every maritime nation; it justified itself in that many hundreds of lives were saved at sea, for example, in the memorable disasters of the *Volturno*, *Vestris*, and *Titanic*; while as a means of telegraphic transmission Marconi's system was a serious rival to the cable companies.

Continuous Wave Transmission

No continuous wireless waves could be transmitted, nor could speech become practicable over the air, until the invention of the thermionic valve made this miracle possible. The story of this invention gives yet another instance of how new developments may be made possible by the use of earlier discoveries. Many years before, Edison had placed a small metal plate inside an ordinary electric lamp, with the idea of stopping the carbon filament from blackening the bulb. He found that when one terminal of a galvanometer was wired to this plate and the other terminal to the positive end of the filament a current passed, although the circuit seemed incomplete. This mystery, the Edison Effect as it was called, was solved eventually by Prof. J. A. Fleming, of London University. By placing a mica screen between the filament and the plate he cut off the current

altogether. This could only mean that the Edison Effect was due to electrified particles (which could not penetrate the mica) jumping the gap from the hot filament to the metal plate. These particles were negatively charged, in other words they were electrons; hence, such a lamp could be used to rectify an alternating current, for it would allow one series of impulses (from the filament to the plate) to pass, but would suppress the opposite series (from the plate to the filament).

Fleming patented his invention in November, 1904, calling it a thermionic valve: "therm" because it had to be hot, "ionic" because the passage of ions produced the effect, and "valve" because it was a one-way action only. This invention was the basis of all modern wireless valves, but its original importance rested on the fact that it provided a rectifier for alternating currents.

The Triode Valve

At the beginning of 1907 Lee de Forest invented a valve with a third electrode, by inserting a wire grid between the filament and the plate; he called it an Audion, for reasons which will be obvious. There was much dispute over the patent, which resulted in a law suit that de Forest lost; nevertheless, in this triode valve he introduced a new and essential idea for speech reproduction. The plate of the Fleming valve could be given a high voltage relatively to the filament, by connecting it to a high tension battery; the filament itself was heated separately by a low-tension current. As the stream of electrons sought to pass from filament to plate they had to pass through the grid; but, by electrifying the grid negatively, some or all of the electrons could be thrown back on the filament again, thus reducing the current or stopping it completely. Also, the more the grid was positively charged, the greater the current to the positively charged plate; thus, by varying the charge on the grid, corresponding variations, but of much greater strength, were induced in the plate circuit. By linking the plate circuit to the grid circuit through a transformer or condenser it was possible to set up a continuous oscillation on the grid from negative to positive and back again. From the alternating (or surging) current thus produced in the grid circuit, a similar surging current could be induced in an aerial which then radiated into space a continuous carrier wave (see Fig. 8).

It remained only to perfect a method of varying or modulating

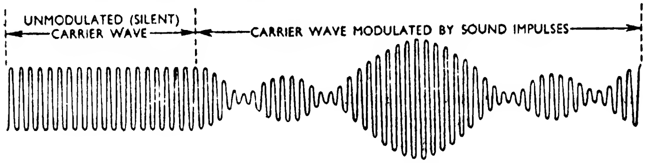


Fig. 8. *Diagrammatic representation of a continuous carrier wave radiated by a transmitter. During intervals of silence the wave is evenly distributed as shown on the left of the drawing; sound impulses impinging on the microphone cause the wave to be modulated as shown on the right.*

this carrier wave in accordance with the variations of current from a microphone (described on page 382) for speech transmission to become possible. The variations of the microphone current are made to increase or decrease the voltage in the plate or grid circuit of the valve with the result that the carrier wave is modulated, as shown in Fig. 8.

All the wireless waves have the speed of light, 186,300 miles per second, or 300 million metres per second; if, therefore, we employ for our transmission a wave of one thousand metres, there must be 300,000 oscillations in the aerial per second, and similarly for any other wave-length. A thirty-metre wave-length requires the enormous figure of 10 million impulses every second; the waves used in television are less than one-fourth of this wave-length!

In the receiving set the valve reverts to its original function of a rectifier, because the current induced in the receiving aerial by the modulated carrier wave is alternating and cannot affect a telephone or loudspeaker diaphragm until it has been made unidirectional. The impulses are also very feeble and must be amplified. The grid-filament ratio in the valve provides a considerable degree of amplification, which can be multiplied to any extent by increasing the number of valves, up to the point where distortion and extraneous noises become intrusive.

Direction Finding

Two very important applications of wireless telegraphy have been the Marconi-Bellini-Tosi direction finder, and the use of short waves for beam transmission.

Marconi was always trying different effects on aerials. In 1905 he discovered that a horizontal aerial erected to receive impulses worked best if its free end was farthest away from the direction of the transmitter, and the aerial itself in the line of the approaching wave; it received less and less when turned round through ninety degrees, being least effective when at right angles to the direction of the transmitter. This discovery made it possible to build frame aerials on ships, by means of which, if they picked up the signals from two or more land stations, the operators could by a simple sum in trigonometry deduce their position, an invaluable aid to navigation during fogs or storms. Moreover, since beams from different stations could be effectively received at any given point, they could also be employed to amuse and mystify the public by making a car travel unattended down a road or a model aeroplane circle round the auditorium of a theatre.

Beam Transmission

Marconi also discovered beam transmission. Although short waves had been used for wireless work to some extent for years, they were left largely to enthusiastic amateurs and did not become commercialized until the early 'twenties; but the elaborate nature and formidable cost of high-power stations had caused Marconi to explore the possibilities of short-wave transmission. It was found that by using special types of aerials the waves could be concentrated in one direction, just as the heat waves are thrown back and made to stream in one direction by the reflector of a bowl fire. If the directional transmitting aerial is orientated in a given direction,

and a receiving aerial is similarly orientated at the far end, the transmission will be picked up by the receiving aerial just as if the short waves were traversing space like a beam of light. By this means good results were achieved with quite small power. This beam transmission cut out the need for the very heavy spark system of the high-powered transmitters, and simplified wireless speech transmission. In 1919, Marconi succeeded in transmitting speech from Caernarvon to Dublin, seventy miles away, on a three-metre band. By fitting the transmitters with revolving reflectors, advantage was then taken of the new discovery to erect a wireless "lighthouse" for ship service at Inchkeith (1922). In a very few years the world was spanned by short waves, a wireless telephone message being sent to Australia from England by the beam transmission method for the first time on May 30, 1924.

Broadcasting

Broadcasting, the advent of which was probably delayed by the First World War, was first attempted in the United States by the Westinghouse Company, who in 1920 began to broadcast gramophone concerts and church services. Marconi seized the idea immediately, and from February 23 to March 6, 1920, his company transmitted daily concerts from Chelmsford. On June 15 of that year Dame Nellie Melba sang "Home Sweet Home" from the same station and was heard over a radius of three thousand miles. Those were the great days of the amateur, who made his own coils with a few bits of wire and could pick up spasmodically some not too distant station. Most listeners used crystal sets—the "cat's whiskers" of which were perpetually slipping off—and were indescribably thrilled by everything concerning the new wonder.

In 1922, the British Broadcasting Company was formed; its station was on Savoy Hill, London, and its call sign 2LO. The Savoy Orpheans, John Henry and Blossom, and the words "Copyright by Reuter, Press Association, Exchange Telegraph and Central News" rapidly became familiar to the ears of thousands of listeners. Within a few years every country had built numerous stations and was broadcasting regular programmes on wavelengths allotted by international agreement. The old hand-made sets, pride of their builders' hearts, were replaced by mass-produced units; the amateur (save for a devoted few) faded out and the professional wireless engineer came in.

For good or ill wireless is now an integral part of the life of the community and is here to stay. It confers many manifest benefits: almost instantaneous communication between different countries, the joining of a whole nation as audience of a single statesman's speech or to some national event, the search for a hunted murderer or a lost phial of poison, the educational broadcasts to schools, the daily weather forecast and time signals, the call to a sick-bed, or the last despairing S O S of unfortunates at sea or in the wildernesses of the Earth.

Pictures by Wireless

These are naturally associated in the mind with broadcasting, because such pictures are carried in precisely the same way as

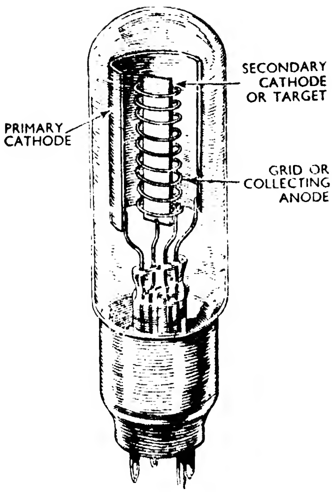


Fig. 9. *Amplifying photo-electric cell. Electrons released from the primary cathode attack a secondary cathode, thereby releasing a much greater stream of electrons.*

sound on the modulations of a wireless wave, but in other respects the process is quite different. The problem here is to reduce a picture to a series of electro-magnetic waves at the transmitting end, and to turn those waves back into the same picture at the receiving end. There are many ways of doing this, but the following general remarks will apply to most of them.

If we examine a picture from our daily newspaper under a magnifying glass, we shall see that it is made up of a multitude of ink dots, which by their relative thickness or fineness (or absence) give the gradations of tone from black to white which build up the picture. By taking a series of rapidly following pictures, as in a cinematograph camera (see page 392), reducing them all to dots, turning those dots into electric waves, and reversing the operation at the far end, we should achieve television of such objects as a moving car or a gesticulating actor. For stills or single pictures, transmission by telegraph has been possible for many years, although it has only been done by wireless since 1926, when Marconi first transmitted pictures from London to New York.

The fundamental process is this: a film of the picture is wrapped around a glass cylinder. While the cylinder turns on its axis a very bright point of light travels slowly down the axis; thus the light-point must trace a spiral on the cylinder, and the whole picture will be covered by this spiral line. When the film is opaque little or no light can pass, but where it is clear there will of course be abundant light. The beam of light, varying in intensity in accordance with the bright places and shadows of the picture, is directed on to a photo-electric cell (see Fig. 9), which is simply a bulb in which an electric current can be excited by means of a beam of light.

Certain substances, particularly cæsium, potassium and sodium, have the power of emitting electrons when attacked by light, the effect being nearly proportional to the brightness of the beam. In some cases, the inside of the photo-electric bulb is coated with such a substance, in others the substance covers a metal plate within the bulb; but in either event the variations of the feeble current which is thus set up can be amplified to any desired extent and sent off on the modulations of a wireless wave to a distant receiver. The current cannot be amplified

direct; but if a toothed disk is made to revolve very rapidly between the light and the picture, it cuts up the light into definite slices or impulses, and these can be transmitted.

At the receiving end they are magnified once more and rectified by valves. The current then enters another cylinder, which rotates strictly in time with the first; round this cylinder a piece of sensitized paper is wrapped, on which the varying impulses build up a facsimile of the picture. Exact synchronism between the transmitting and receiving cylinders is essential, just as it is with television, otherwise the received picture will be distorted; this synchronism is ensured by inserting special control waves in the transmission.

Television

Television is an extremely complicated matter. It could not succeed but for the well-known property of our eyes by which they retain the impression of a picture for a short space—roughly one-tenth of a second—after we have observed it. In those books which showed silhouette pictures of dancing and such subjects as the Jefferies-Corbett prize fight, each picture of the book presented the figures in a slightly different attitude. By passing the edges of the sheets rapidly across one's thumb the characters appeared to move, thanks to the eye's "persistence of vision." Television, like the cinematograph, takes advantage of this fact, by presenting a series of separate pictures so fast that the characters appear to move. Any series shown at a rate exceeding ten or twelve per second will seem continuous; the number actually provided in television is twenty-four or twenty-five every second.

The television frames are small, the old British Broadcasting Corporation experimental pictures having a size of seven inches by three inches, but frames in future will probably be five inches by four inches or an enlargement in the same ratio. There are many systems of television, but at present they all employ some method of cutting the picture up into very thin horizontal slices, starting at the top left-hand corner (see Fig. 10). Each of these slices contains a great variety of lights and shades, which must be broken up into electromagnetic waves.

Modern systems break up the pictures, each of which has to be transmitted in one twenty-fifth of a second, into 405 horizontal lines. To avoid flicker, the lines are interlaced, that is lines 1, 3, 5, 7 and so on to the end are transmitted first, then lines 2, 4, 6, 8, etc., all, of course, far too fast to be perceived. Since there are 10,125 lines per second, each with its range of shades, the photo-electric cell or cells employed must respond to several million stimuli every second; moreover, only very short waves can be employed in the transmission. A wavelength of 6·6 metres has been recommended for future transmissions in Great Britain, a shade less than the television transmitter at Alexandra Palace, London, employed before 1939, when it sent out forty-two million waves each second.

Television Problems

With this background, some of the problems that have afflicted television engineers become evident. Taken in order of time, these

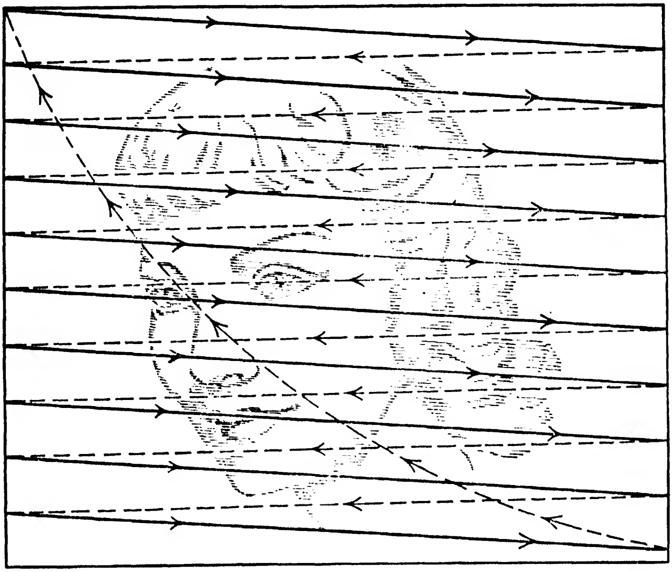


Fig. 10. *How a television image is broken up into horizontal lines by the scanning apparatus of a television camera. In practice there are 405 lines, and the whole picture is scanned in one twenty-fifth of a second.*

problems are the illumination of the subject sufficiently to show all its lights and shadows, the splitting up of that illumination into innumerable patches which can be converted into current, the amplification of such very minute impulses sufficiently to permit their transmission, and the reverse series of operations at the receiving end.

Illumining the subject is called scanning, a word which, despite much popular misuse, means to examine narrowly. One method is to pass a bright spotlight from point to point over the subject, so rapidly that one is not conscious of it; there is a better way, to which we will refer in a moment. Another method is to employ a set of brightly lighted mirrors, arranged upon a revolving drum. Next comes the chopping-up process. The Baird television system formerly employed three rapidly revolving disks, the first of which contained small lenses spirally arranged, and the others slots and a groove by means of which the images received by the lenses could be further cut up. As the disks revolved, each lens traversed one line of the picture, and as there were only thirty lines per inch the result was necessarily very coarse-grained; moreover, the system made extremely heavy demands on the photo-electric cell, despite its wonderful sensitiveness.

New methods were therefore tried, involving a quite different

principle, and one of them, the cathode-ray tube, proved highly efficient and appears today to hold the field. In a cathode-ray tube the electrons from the cathode (or filament) rush across to the anode and may have sufficient velocity to stream beyond it. By using magnets placed outside the tube, or magnetized deflector plates within it, the stream of electrons may be directed like a gun or a paint-spray, so as to cover the whole inner surface of the far end of the tube, let us say from left to right and top to bottom, at perhaps 405 times a second. On this basis Dr. V. K. Zworykin invented the iconoscope, or image-viewer, the principle of which is now used by the B.B.C.

The Iconoscope

The iconoscope (see Fig. 11), comprises essentially a large cathode-ray tube, shaped like a glass decanter with a long, tilted neck. In the bowl portion a metal plate is fixed vertically, the side facing the neck being coated with a thin film of mica on which a multitude of tiny dots of silver coated with cæsium have been applied. The back of the plate is connected electrically through the wall of the bulb to the amplifying and transmitting system outside (see Fig. 12). The screen is in line with a powerful lens outside the bulb, this lens being focused on the subject. Thus, when lighted up the subject covers the whole screen with its lights and shadows, each tiny sensitive photo-electric cell receiving its part, and as the subject moves the minute currents within the photo-electric cells vary in sympathy. The neck of the flask contains the cathode, from which a stream of electrons pours out. It traverses one, two, three or even more anodes (which are disks with a hole in the centre) like an exceedingly fine jet; this

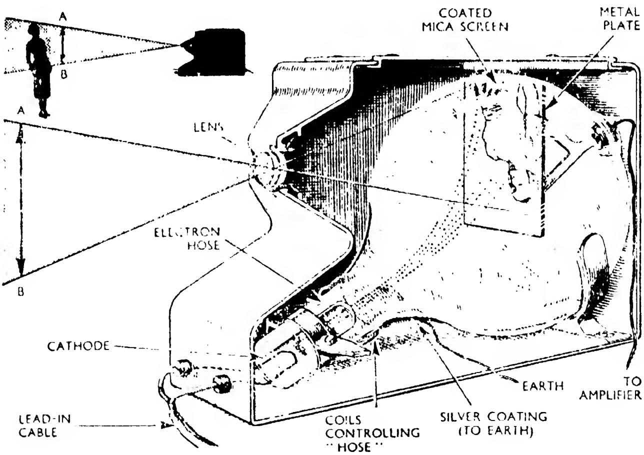


Fig. 11. *Part section drawing of the iconoscope, showing the electron stream scanning the screen on to which the desired picture has been focused.*

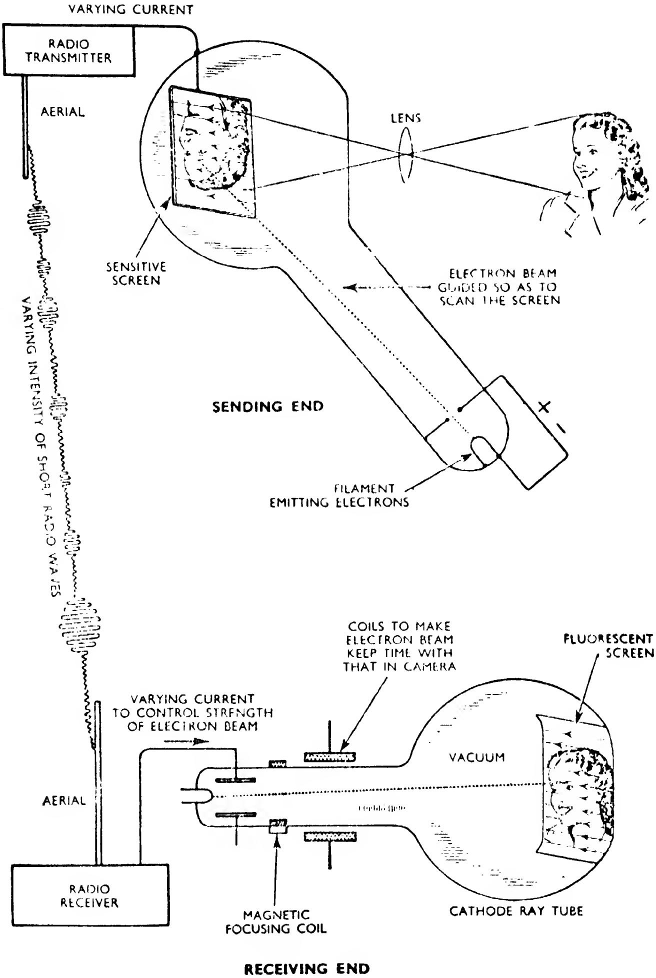


Fig. 12. *Diagram showing the principle of television. The electron beam in the television camera (shown top right) sets up a varying electric current which the transmitter translates into radio impulses. From these impulses the receiving set again reproduces the varying current, which then regulates the strength of the electron beam illuminating the fluorescent screen of the receiving set (seen at the foot of this illustration).*

apparatus has been aptly named an electron-gun. By the action of the deflecting plates, the jet is then made to cover the entire picture from top to bottom in 202½ horizontal lines, followed by the remaining 202½ lines and, as the jet passes each tiny grain of cæsium, the cæsium discharges electricity in proportion to the amount of light shining on it, the result being an impulse of appropriate strength through the back of the plate to the wire outside. Subsequently, these electric impulses are amplified and transmitted.

At the receiving end, the electric impulses again pass to a cathode-ray tube, the electrons from which play upon a fluorescent screen at the far end, the outside of which shows the televised picture. The electron stream moves over the fluorescent screen in the same way as and in tune with the stream in the transmitter's iconoscope, and the strength of the stream is varied by the incoming wireless impulses. As the electron stream hits the screen, the part of it which is struck glows more or less brightly according to the strength of the electron stream, and a picture is built up on the outer side corresponding to what is being "seen" by the iconoscope (see Fig. 12).

Regular television broadcasts, suspended in 1939, were resumed by the British Broadcasting Corporation on June 7, 1946, and on June 8 the Victory Parade in London was televised.

The possibility of transmitting in colour has been under investigation for years, and two-colour transmissions have been achieved. Television is certain to make great progress in the next few years, and indeed all departments of radio have so far advanced under the stimulus of war that big developments may be expected as the various improvements are made available for civilian use.

The Cinematograph

The cinematograph is essentially a twentieth-century invention, but its roots go far back. Mid-Victorian machines like the zoetrope gave the moving-picture effect by arranging a set of pictures round the inside of a drum, and then either passing them rapidly before a slot, or (which comes to the same thing) revolving the slot before the pictures. Obviously, there could be no cinematograph without films, and celluloid was not manufactured till 1869. By about 1878 photographs were being printed on lantern slides and shown in a magic lantern. Ten years later, a celluloid film was coated with light-sensitive silver salts, and next year (1889) the Eastman Kodak film first appeared. On March 22, 1895, a demonstration of moving pictures was given by the brothers Lumière at Lyons; they called their machine a cinematograph, and the name has taken root.

The cinema camera is admirably adapted to a moderately difficult job. The standard film is 1·38 inches wide, each picture being ·748 inches deep; a length of up to one thousand feet is carried in a light-proof magazine. The forward motion of the film, at twenty-four pictures per second, must carry about eighteen inches of the film before the lens in twenty-four jumps every second; but trick photography, such as slow-motion pictures, requires a much faster movement. The slots in the film engage with the teeth of two

sprocket wheels, which pull it forward to be fed through a slot or "gate" behind the lens. Here a mechanical claw engages the slots of the film, so as to pull it down flat and hold it still for a fraction of a second, while the picture is being taken. Then the claw pulls forward another section of film, and so on. At the same time a shutter behind the lens keeps pace with these movements, exposing the film only when it is still.

The developing of films has become a high art. Full-length films are developed in long, pipe-like tanks, the film afterwards being dried on revolving drums in a warm room. This film of course is a negative, precisely like the negative from any ordinary camera. It therefore has to be closely fastened to a new length of film, the two being passed through a "gate" together under a powerful light; the positive is then developed and fixed, and the film is ready.

The cinematograph projector works at the same speed as the camera, twenty-four pictures a second, and again each picture must be held still for an instant so that the eye may have time to grasp it. In the projector the sprocket wheel which feeds the film forward is attached to a wheel shaped like a Maltese cross (see Fig. 13). A third wheel, which revolves steadily, carries on its face a raised disk with a recess in its rim, and a projecting pin. The edge of the disk holds the Maltese cross still until the pin enters one of the slits on the cross and twists it forward a quarter turn. The cross is then locked again, and so on.

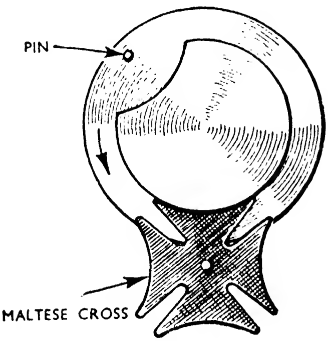


Fig. 13. *The Maltese cross mechanism on a cinematograph projector which checks the movement of each picture for an instant.*

Sound Films

One is so used to "talkies" nowadays that the thrills and quaintness of the old silent films, with their over-emphasis on action, their captions grave and gay, and the gramophone accompaniment which so often failed to synchronize with the movement of the actors' lips, are almost forgotten. Many who saw *The Singing Fool*, or *The Donovan Case* in 1928–29 and similar early talkies, regarded the innovation, though wonderful, as no improvement. Despite defects which a sensitive ear can still pick up (for a short time only, because one insensibly acquires the "atmosphere" of the screen after watching it for a few minutes), the modern sound-film is an achievement of a high order. The sound track is impressed on the film beside the picture so that the sounds synchronize with the appropriate movements of the actors, and so on. The pictures on the films are, in this case, about one-tenth of an inch narrower than silent films, to make room for the sound track.

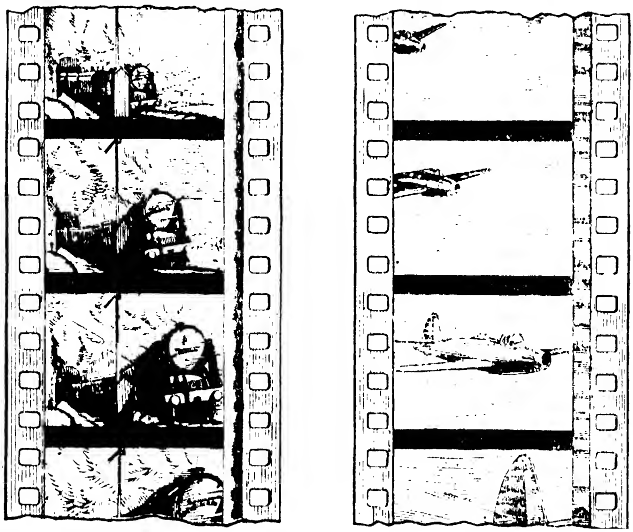
Sound tracks themselves are of

two kinds, known as variable area and variable density tracks respectively (see Fig. 14).

In variable area films, the sound camera contains a lamp which throws a bright beam of light upon a magnetically controlled mirror, which is wired to a microphone in the studio, the microphone being out of the picture, above the actors' heads (see Fig. 15). When an actor speaks, the sound waves, transformed to electric impulses by the microphone, agitate the mirror; hence the beam of light shivers, moving from side to side in sympathy with the sounds. This moving light-beam is directed upon a very fine slit behind which the sound track of the film is being drawn at a uniform speed. For a loud sound the light beam traverses the full length of the slit, which is of course the full width of the sound track. The smaller the sound the shorter is the distance along the slit traversed by the light beam.

With variable density sound tracks, the light shines upon the whole track through the slit and is varied in intensity according to the strength of the sound impulses. The result is a multitude of horizontal straight lines; where these are close together strong noises occur, where they are more scattered quieter sound is indicated.

For both systems, the sound recording may be done either when the film is taken or subsequently. In the majority of studios it is usual to record speech at the time of



VARIABLE AREA VARIABLE DENSITY

Fig. 14. *Two distinct strips of sound film showing the appearance of variable area and variable density sound tracks. Some systems produce variable area tracks of a somewhat different appearance by embodying the same principle of horizontal lines of varying length.*

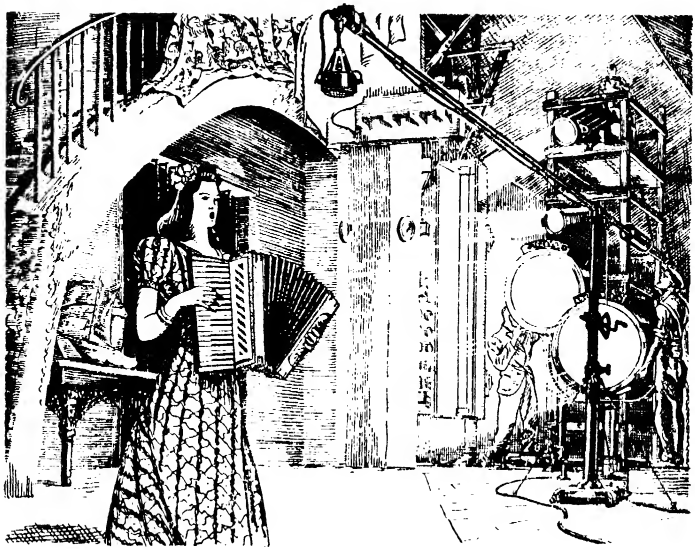


Fig. 15. *A studio scene during the making of a sound film. The microphone is suspended above the singer's head, outside the range of the camera.*

shooting the film, whereas incidental music and other noises can be added afterwards.

The film projector has a sound gate underneath the picture gate, the film running through it immediately the picture has been shown. Between the two gates, however, the jerky motion of the separate pictures must be reduced to continuous motion, otherwise the sound would be broken up, too; this continuous motion is achieved by means of a steadily revolving sprocket wheel between the two gates. Behind the sound track is a powerful light which shines through the track on to a photo-electric cell. As the sound track varies in density, so do the light rays reaching the photo-electric cell. In the manner previously mentioned, these impulses are then led away, magnified by wireless valves, and finally fed to a loudspeaker which is usually placed behind the screen.

Trick Cinematography

The camera never lies, but it can easily be made to give quite false impressions. Thus, by running a film backwards through the camera and then showing it in the normal way on the projector, a ball struck by a cricket bat can be made to go back to the bowler, or a trunk hurled out of a window rise to that window from the pavement ten stories below. For slow-motion pictures the original film must be taken much faster, since if shot at four times the normal speed, the resultant action will appear at only one-fourth of its real speed; con-

versely, by slowing down the shots a slow-moving train may be made to rush most realistically upon a person who has been tied by the villain to the rails!

Special cameras are used for such freak photography, slow-motion cameras in some cases being able to take five thousand pictures in a second. Such cameras, of course, have a very practical value when investigating ultra-rapid events like the breaking of a piece of glass or the behaviour of a bullet in flight. Where an actor plays two parts simultaneously in a film, he is first "shot" in one of his roles, one-half of the film being screened from the light; he is then "shot" again in the second role on the other half of the film, great care of course being needed in respect to timing. At least one good book is devoted entirely to these tricks of the camera.

Colour Films

Colour cinematography is, naturally, more complicated and costly than the black-and-white process, and many technical difficulties had to be overcome before satisfactory results were achieved. In the early days colour films were produced by means of a two-colour process—usually employing rust red and green-blue—but it was impossible to achieve a full range of colours.

The range of colours in the visible spectrum, which together make up white light, are light rays of slightly different wavelengths. The colour of any opaque substance is due to the fact that it absorbs some of these rays but reflects back others. Transparent substances absorb some light rays but allow others to pass through. Light rays which enter the eye affect substances in the retina which are sensitive to red, green and violet light, respectively. The sensations thus set up are combined and interpreted by the brain as the various colours which we see. Colour films follow a similar process by combining three colours in various proportions to reproduce the natural hues; red, green and violet are mainly used, but in some processes, called the subtractive processes, the secondary colours magenta, cyan blue and yellow are employed.

Three main methods of securing colour films are at present employed, these being represented by the Technicolor, Dufaycolor and Kodachrome systems. The first-named employs a rather elaborate camera which analyses the picture into three colours and projects them on to three separate black-and-white films. During development the images on these films cause the gelatine surface to swell slightly to give a matrix printing surface. Each film is then coated with the appropriate dye (magenta, cyan blue or yellow) and the three are finally pressed, one after the other, against a fourth, unsensitized, strip of film which thus receives the dyes from them by a process analogous to mechanical three-colour printing and becomes the positive print which is screened in the theatre.

The Dufaycolor type needs no elaborate camera, the photographic image being received on a film upon which minute spots of colour —red, blue and green—are registered. The differing wavelengths of light reflected by the scene photographed each affect the appropriate spots of colour, and when the silver image has been developed away a colour record remains.

The third method, employed by

Kodachrome and Agfacolour, has three sensitive layers upon the film strip, each layer containing a chemical substance which, when developed, acts with the developer to form colour.

A method of recording colour by means of a colour wheel and three separate images has been almost entirely superseded by the methods outlined above.

Medical Discoveries

Prolific indeed has been the crop of medical discoveries, and equally great the improvement of surgical technique, during the twentieth century. Much of this advance is due to the fierce stimulus provided by two world wars, when hundreds of thousands of wounded men provided hosts of problems that had to be solved, and solved at once. Much is also due to the succession of discoveries in physics, which have made such things as radium treatment for cancer, and medical radiology in general, desiderata for a well-equipped modern hospital. There has also been a remarkable advance in our knowledge of the effects of drugs, which in many cases permitted serious operations to be postponed or even averted. We can only glance at a few of the most striking items.

X-rays

Early diagnosis is of primary importance in the treatment of disease or injury to the human body. This is usually a simple matter in the case of skin abrasions or disease but many defects inside the body present a different picture —some symptoms quite often belie the damage that has occurred. Anything which helps the physician to make an early diagnosis cannot therefore be lightly dismissed as "just another gadget." The discovery of X-rays is of supreme importance in this connexion.

In 1896, Professor W. K. Röntgen noticed that some photographic plates which were stored in a drawer had become fogged. He soon found that this was due to a stream of electrons which had emanated from an adjacent Crookes's tube, the precursor of the modern cathode-ray tubes.

When Röntgen passed an electric current through a gas in this tube, he noticed that a chemically coated screen in the room gave off fluorescent light; for the stream of particles (electrons) from the negative or cathode end of the tube was producing a new and, at that date, mysterious kind of radiation.

Röntgen discovered that these rays would pass through black paper and even the door of a room. As they lay in the ultra-violet part of the light-band, far beyond ordinary visible light, and for other reasons, Röntgen doubted whether they were light rays at all. He therefore named them X-rays.

X-rays are now known to be light-rays of short wavelengths, which can be produced from many substances. Some of these substances are referred to later in this chapter, but the name X-rays has continued ever since to be applied to those rays which emanate from an X-ray tube (see Fig. 16).

Although the nature of X-rays was unknown for many years after Röntgen's discovery, immediate advantage was taken of their remarkable power of penetration. For the first time it was possible to photograph certain organs of the body. The reasons for this are twofold: (1) due to the fact that X-rays

are absorbed more readily by compact substances, such as bone, than by loosely-knit substances, such as flesh, and (2) due to the manner in which they affect a photographic plate.

When a hand is placed between an X-ray tube and a photographic plate, the bones absorb more X-rays than the rest of the hand. Thus, the rest of the hand appears as a dark shadow on the plate and the bones appear light. A bullet or a needle embedded in the flesh appears as a white shape on a photographic plate, while a fractured bone appears as two light shapes separated by a thin black mark—indicating the site of the fracture.

It is not difficult to appreciate how X-rays have enabled the surgeon to operate more surely in these cases, but there still remained the problem of taking photographs of non-opaque organs, such as the alimentary tract, through which food passes. This problem was solved by giving the patient a meal of bismuth carbonate (about 2 oz. in 10 oz. of porridge). This concoction is so opaque to X-rays that a shadow of the food, as it passes through the tract, is thrown on the photographic plate. The outline of the food does, of course, coincide with the lining of the alimentary tract. In recent years, many dyes, such as a ten per cent solution of sodium iodide, inoselectan, and tetraiodophenolphthalein, have been used with remarkable success.

In the early days of X-ray photography, the radiographers noticed that exposed parts of their skin were suffering from a serious type of inflammation. In addition, some of them noticed that their hair was falling out. A means soon had to be devised for their protection and, today, all radiographers are compelled to wear suitable protective clothing.

In passing, it should be noted that radiography is now used extensively in industry, especially in regard to revealing the defects in badly moulded castings and unsatisfactory welds.

X-ray Therapy

The harmful effect of X-rays on human tissue led to the belief that the rays could be employed for the destruction of malignant growths and the treatment of certain skin diseases. Great care has to be exercised in this connexion due to the destructive effect of X-rays on healthy and malignant cells alike. In fact, the dosage is of primary importance, and the modern view is that the bigger the dosage and the shorter the duration (within limits) the better the result. A machine has been assembled with an output of one million volts, while another of two million volts has just been completed. Finally, there is an even larger one of twenty million volts in course of construction. These machines (Betatron) involve the principle of the cyclotron (see page 412), enabling very penetrating X-rays to be produced by high-speed particles. It remains for future research to ascertain what results these titanic machines will produce.

Radium

X-rays are by no means the cure-all for malignant disease, and modern physicians hold various views about their propensities. Another step on the ladder was reached in 1896, when a young scientist, A. H. Becquerel, was

trying to obtain similar radiations from phosphorescent bodies. By chance, he found that uranium crystals would affect a photographic plate, even when it was in complete darkness. Following this up, he discovered that the radiation causing this effect carried with it a sort of "atmosphere" of its own, which possessed electrical properties. These uranium rays were quite feeble; they penetrated aluminium or paper, but not denser substances. It was at this point that Madame Curie came on the scene.

Madame Curie

Marie Curie (née Sklodowska) was the daughter of a Polish teacher. Having dabbled in politics, she was forced to flee from Warsaw to Paris, where she lived on the scantiest fare, earned by occasional teaching and by her work as a bottle-washer at the Sorbonne. After a time she was appointed to assist Pierre Curie, an ardent but poor young scientist, who was then working on electricity. The student and his assistant fell in love, and they were married in 1895. Life was difficult, but Madame Curie stuck to her studies, and three years later she graduated in mathematics and physics.

Her curiosity having been aroused by Becquerel's work, she began to examine all the compounds of uranium in a search for the source of the rays; thorium was also studied. The substances were tested by the very delicate yet simple electroscope, the sensitive gold leaves of which invariably collapsed when the "atmosphere" of the radiation came within range. After much labour, it became clear that uranium itself was not the source of the strongest effect, because pitch-

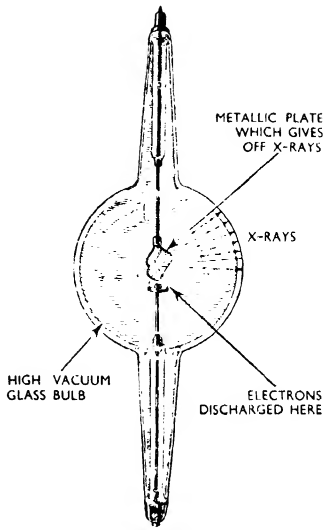


Fig. 16. *Coolidge X-ray tube, showing how X-rays are given off by the metallic plate.*

blende yielded one that was four hundred times as powerful. This substance was separated, being named polonium, in honour of the discoverer's country. All this work went on while the Curies were still in very humble circumstances.

The Austrian government generously gave the Curies one ton of pitchblende from the State mine, Joachimsthal. The pitchblende was refined first in a factory and afterwards in the Curies' laboratory, where at last it was reduced to a reasonable bulk. It now became apparent that something infinitely more potent than polonium lay hidden in the ore; they partially separated it, until a bromide of the new substance lay, like grains of white salt, in their test tube (1902). Its quantity was ridiculously small,

yet it displayed a radioactivity two million times that of uranium, and it continued to hurl forth its ceaseless energy, day after day, month after month, with no apparent loss. This substance, the most wonderful that has ever been discovered, was radium (see Fig. 17). The pure element was not obtained for another eight years (1910), by which time Madame Curie was a widow. In the whole history of science there is no episode more moving than that of this self-taught little woman so patiently and indomitably hunting down the sources of radiation.

It will be remembered that A. H. Becquerel discovered by chance that uranium crystals would affect a photographic plate. By another accident he again stumbled on an important discovery. He once carried a small tube of radium in his vest pocket. Subsequently he developed symptoms of burning beneath the skin, and he was lucky to have escaped with his life. The knowledge that radium could destroy tissues led at once to the idea that it might be made to do so deliberately, especially with the dreaded disease of cancer.

Dr. Duane soon found a means of purifying a little radon (a radioactive substance), which was then forced by a pump into tiny glass capillary tubes only one millimetre to fifteen millimetres long. These tubes, provided with minute hooks, were then shot from long tubes or needles into the cancerous growth; by means of the hook they could be withdrawn again after various periods up to several days. Cancer of the breast, cancer of the womb, various skin cancers, cancer of the bladder and even cancer of the stomach, have been so treated.

At first, the difficulty was to provide the right dosage, since the radium killed healthy and bad cells alike, but steadily the technique improved. Today, doctors claim that if many cancers are diagnosed in time they can be cured, and radium is a most powerful agent.

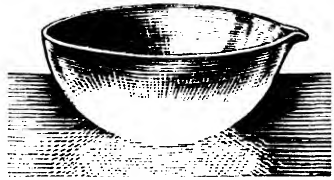


Fig. 17. *Drawing showing the luminosity of a speck of radium (about the size of a pinhead) lying in a glass bowl in a darkened room.*

H.11 Extract

The problem of curing malignant disease in its advanced stages remains unsolved. Much useful research work has, however, been carried out by the Hosa Research Laboratories at Sunbury-on-Thames in particular. A widely accepted view is that, for some reason, possibly due to irritation, one cell goes mad, that is its life becomes disordered and malignant. It is believed to be no longer subject to the controlling influence of growth-inhibiting substances. Like other cells in the body, it starts to reproduce and that one cell becomes two, these two become four, and so on.

Originally these malignant cells are confined to one particular part of the body, so that if their presence is detected in time they may be removed by surgical procedure, destroyed by radium if accessible, or possibly by X-rays if inaccessible. Reproduction of these cells is, however, usually rapid and they

soon get into the blood stream and are carried to other parts of the body. If this happens, it is impossible to effect surgical procedure, or employ either radium or X-rays in most cases.

The problem which the Hosa research workers have been trying to solve is to prevent these cells from reproducing wherever they may be situated. Since it is known from the discovery by J. H. Thompson, director of the Hosa team, that the parathyroid gland produces substances which control the growth of healthy cells, it is not unreasonable to suppose that if enough of these substances are administered to the patient the disease will be checked or even cured. These Hosa workers have, therefore, produced an extract which contains such substances in large quantities and the extract, known as H.11, is administered to the patient.

It is only fair to say that remarkable results have been achieved with H.11 even in advanced cases of cancer, and there is hope that this extract, or some improved form of it, will prove to be the weapon which physicians have been seeking for many years past.

Insulin

Behind the stomach is an organ, known as the pancreas, which produces what may well be called a miraculous substance. If, for some reason, this substance is in short supply, the person suffers from a chronic disease known as diabetes mellitus. This form of diabetes is characterized by an excessive amount of sugar in the urine (although the presence of sugar in the urine alone does not necessarily mean that a person is suffering from diabetes). In the later stages of the disease, the patient falls into a coma and, if prompt treatment is not administered, eventually dies. The serious nature of this disease cannot, therefore, be overestimated.

Until 1925 the disease was incurable and, in fact, is generally regarded as such today. It was, however, in that year that a young Canadian doctor, named Banting, assisted by a student named Best, made a series of experiments. These were largely based on the isolation of various extracts from sheep's pancreases.

This was not a new idea, but Banting and Best succeeded in producing the only extract that was of any value to diabetics. That substance they called insulin.

It needed much research to ascertain the properties of insulin. Broadly speaking, insulin regulates the percentage of sugar in the blood. If the percentage is too high, insulin converts the excess into starch and stores the starch in the liver, muscles and skin. By administering a supplementary supply of insulin to a diabetic, Banting and Best discovered that such a patient could lead a normal, healthy life, so long as he continued the treatment.

The disadvantage of insulin, however, is that it cannot be taken orally because the digestive juices of the stomach destroy its magical properties. Insulin has therefore to be injected daily into the patient.

Vitamins

As long ago as 1880, Lunin observed that when an animal was fed on a "pure" or synthetic diet it did not thrive and finally died. The late Sir F. Gowland Hopkins

tested this idea (1906) by feeding eight rats on pure food and a second eight on natural food. After eighteen days, the animals which had been fed on the artificial food had stopped growing, whereas those fed with natural milk food were thriving. The diet was then reversed, the natural milk being fed to the stunted animals; these began almost at once to grow, whereas the others stopped growing and lost weight rapidly.

Many other observers now took up this study, for it was clear that there must be something in the natural milk which promoted healthy growth, but which the pure food did not possess. It was also well known that the Oriental disease of beriberi arose because polished rice lacked the husks which contained a vital substance; when some of these husks were included with the meal, beriberi was absent. In 1911, Funk found a very minute quantity of a crystalline substance in such rice polishings; and as this substance was apparently essential to life, he called it a vitamine—vita for life, amine because it was derived from ammonia. This substance was vitamin B.

It soon became apparent that certain other substances occurred in all food-stuffs, the absence of which brought about disease and often even death. A number of other vitamins were traced; but as they were known only by their effects they were not given specific names, the series being called vitamins A, B_1, B_2, etc., C, D, E, K, and so on. Not for many years was the composition of a vitamin really known; but in 1937 Szent-Gyorgyi was awarded the Nobel prize for the artificial production of vitamin C. In the same year, vitamin B_1 was also successfully synthesized, as well as crystalline vitamin A. Vitamin K, or a manufactured substance indistinguishable from it, was located in 1939.

Sources of Vitamins

Almost all vitamins occur in animals' livers, fresh vegetables, milk and its derivatives cream and cheese, eggs, and some in cereals. It was found during 1912-1915 that butter-fat and cod-liver oil nourished young rats, whereas lard did not. When butter-fat or cod-liver oil was withheld, the rats developed eye diseases. The same thing occurs in human beings and in many other animals. The vitamin concerned, vitamin A, is essential for growth; when it is absent, first disease and then death follows. Vitamin D, which is often associated with vitamin A, not only occurs in green plants, but is also produced by the action of ultra-violet light on something in the human skin and tissues; in the absence of this vitamin rickets occur, hence the value of ultra-violet ray treatment for that disease. Vitamin D appears to control the balance of calcium and phosphorus in the body, the bone-making substances. Vitamin B_2 is found in yeast, milk, meat and green vegetables. The presence of vitamin C is essential to combat scurvy; it is found in citrus and other fruits, and in raw vegetables, all of which are known remedies for scurvy. Without vitamin E, although the sexual act may occur, conception may not take place.

How vitamins act nobody knows. They may play in the blood the same part that catalysts play in chemistry, agents which will cause changes to take place much more

rapidly, even when they are present only in minute quantities. For instance, pure hydrogen and oxygen may safely be mixed together and nothing will happen, but the minutest trace of a foreign substance such as platinum will cause an explosion, resulting in the formation of water. Vitamins then may be organic catalysts. So small are the quantities that one ten-millionth of a gram of vitamin D per day protects rats against rickets.

Dried Blood

It is trite to say that the heart ceases to function when a person suffers from an excessive loss of blood. Blood can, however, be given to such a person, provided a suitable donor, that is a person in the same blood group, is available and willing to undergo a blood transfusion. In peace time this does not normally present much difficulty, but on the battlefield the situation is altered radically.

In the Second World War many lives were saved by the timely discovery (1940) of a method of drying blood so that the dried blood could be taken to the battlefield, moistened when needed, and given to a casualty suffering from excessive loss of blood. The containers had, of course, to be labelled with the relative group number of the contents. The process consists of extracting the unwanted red corpuscles from the blood, drying the white fluid (blood plasma) which remains, and converting it to powder.

The Iron Lung

A medical aid which, like penicillin, was at first too costly and scarce to be made available to more than a few patients, but which is now becoming more readily available in hospitals generally, is the Drinker Respirator, familiarly known as the iron lung.

Its origin may be traced to the great epidemic of infantile paralysis which swept over the United States of America towards the end of the First World War. After rendering the limbs useless, the disease affects the chest and the patient finds it almost impossible to breathe. Such cases had to receive artificial respiration continuously. It was given by firemen or special squads, working in shifts perhaps for days on end, before the sufferer's lungs would work naturally again.

Dr. Philip Drinker, assisted by Mr. L. A. Shaw (both of Harvard) determined to make the natural air pressure do this work instead. They built a metal chamber in which the patient was placed, with only his head protruding. On the undercarriage of the machine was a small electric motor, which worked a suction pump connected to the chamber. The suction was interrupted by a slowly rotating valve, which allowed the pump to draw air only at regular intervals. Thus, when air was drawn out of the chamber the reduced weight per mitted the lungs to expand, but when on the next stroke air was allowed in through the valve the normal air pressure of the room gently deflated the patient's lungs again.

The iron lung has saved many lives under dramatic circumstances, and at one time such machines as existed had to be rushed around from one hospital to another, so small was the supply. The need for more machines was driven home—in the United States at least—by a case at San Francisco where one

hospital, possessing only a single iron lung, had to decide whether to treat a married man of twenty-five or a single woman of thirty. The doctors decided for the man, who recovered. The woman died.

Drugs

More extensive use is being made of drugs today than ever before in the history of mankind. This is largely due to the wide range which is now available for the treatment of disease. Drugs have, of course, been used for hundreds of years; an example is quinine, which has been used as a preventative measure against malaria for over three hundred years.

Before describing some of the many drugs which have been discovered during the twentieth century, it is necessary to explain how disease may be spread or transmitted from one person to another. Quite obviously, there must be disease carriers—such as lice, flies, mosquitoes—and if these are not annihilated, the organisms which produce the disease can be transmitted by the carriers from one person to another. Once a disease organism has been carried to a person, a means has to be devised also for destroying or drugging the organism which has been deposited in that person.

Mepacrine

One of the most prolific disease carriers in hot climates is the *Anopheles* mosquito which carries a minute protozoan parasite, known as *Plasmodium vivax*. The mosquito bites its victim, thus leaving the parasite in the red blood corpuscles. An asexual cycle of reproduction is started and, subsequently, malaria ensues (see Fig. 18). The purpose of taking quinine is to prevent the parasite from commencing the reproductive cycle.

When the world's supply of quinine diminished during the Second World War, a substitute had to be found. Fortunately, it did not take a young Britisher long to produce a substance, known as Mepacrine, which can be likened to a synthetic quinine, and is now considered one of the best preventative measures against malaria.

D.D.T.

Of course, the obvious way to prevent malaria is to destroy the mosquitoes in their breeding grounds, but this is not always possible because mosquitoes can breed in swamps, rainwater tubs, ponds and so on. Many things have been tried, some with good results, but there is now hope of solving the problem by the distribution of a white, sweet-smelling powder, known as D.D.T. Whether it will be possible to spray swamps and large breeding grounds with this powder in sufficient quantities remains for the future to determine.

All overseas troops were familiar with D.D.T. during the Second World War. Their clothes and bedclothes were sprayed every few months with this powder, as a preventative measure against many types of pests, notably lice which carry the parasite that is responsible for typhus. The ordinary household use of D.D.T. hitherto has not always been too satisfactory, possibly because the substance is sold in a very diluted form.

Penicillin

Man continuously wages war against certain types of bacteria which are responsible for many

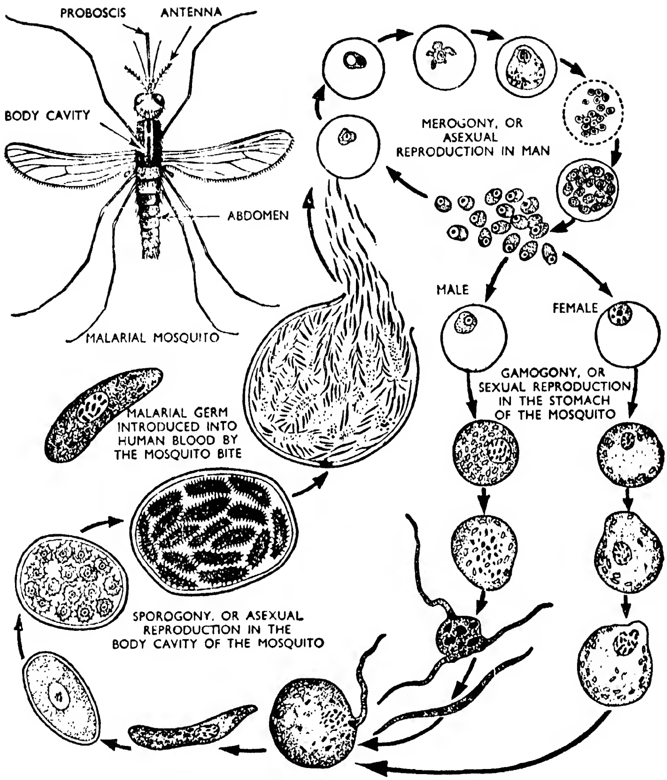


Fig. 18. *Malarial mosquito (top left) with (below) the malarial germ which is introduced into human blood by the mosquito's bite, and (right) the three reproductive cycles of the germ which take place in Man, the stomach of the mosquito and the body cavity of the mosquito respectively. The three illustrations are all greatly enlarged but not in the same proportion.*

kinds of disease. These minute organisms are so difficult to study that science, at one time, was presented with what seemed an insoluble problem.

However, an accident occurred, not an infrequent event in medical research, which eventually changed the whole outlook of our scientists. It happened in St. Mary's Hospital, London (1928), when Alexander Fleming (now Sir Alexander Fleming) was examining some culture plates of staphylococci growing in a solution of agar. These cocci are one of many types which are responsible for various diseases, including meningitis, pneu-

monia, septic wounds, carbuncles, tetanus, gonorrhea, diphtheria, and puerperal fever.

Fleming noticed that a green mould was growing on one of his culture plates. A minute spore must have invaded the colony, possibly during previous examination, settled and started to reproduce. It is to Fleming's credit that he did not destroy the plate; instead, he examined this foreign mould.

The first thing he noticed was that the cocci in the region of the mould were either dead or apathetic. He then identified the mould as *Penicillium notatum* and, later, extracted a solution from it which he called penicillin. There is not space to describe what led Fleming to believe that it would be possible to extract from this mould a solution which would heal septic wounds and combat certain forms of bacterial disease.

Production Difficulties

Alexander Fleming's researches were for a time doomed to failure. This was due to the difficulty of producing a pure solution of penicillin in large quantities. Also, at that time (1933), a drug, derived from a substance known as prontosil, came on the market. This drug (see page 407) possessed many of the properties of penicillin but soon lost a good deal of favour due to the harmful results that followed in certain circumstances.

However, in 1938, Professors Heilbron and Florey became interested in Fleming's original paper on penicillin. Later, they co-opted the services of another brilliant scientist, Dr. N. G. Heatley, who discovered a new method of producing a pure solution of this wonderful drug. But he also was unable to devise a method of producing it in quantities that would be sufficient to meet the exigencies of war.

Eventually, in 1940, some English scientists were asked to visit the United States of America with the object of demonstrating penicillin. The Americans were keenly interested and immediately set to work to build gigantic laboratories for the production of this drug. Following this, the British Government sponsored the building of huge penicillin plants in Great Britain.

Now that penicillin is available in large quantities, we read of the astonishing results which have been achieved in the treatment of wounds and burns, and also against the germs which cause pneumonia, anthrax, tetanus, diphtheria, meningitis, puerperal fever, gonorrhea, and many other diseases. Time alone, however, will prove the value of this substance.

For most complaints a solution is injected into the veins, but there is penicillin cream (which must be kept in a refrigerator) for the treatment of carbuncles, etc. There is also penicillin powder which is dusted on to severe wounds and burns, and, finally, there is a lozenge for the treatment of mouth and throat infections. Mankind will always be grateful to the scientist who discovered the remarkable qualities of the mould which gave birth to the production of penicillin.

The Sulphonamides

Drugs, besides halting certain diseases and giving relief from pain, have their dangers, as everyone knows who has studied the history of morphine and opium. Drugs are not only specifics, they are also

poisons, and should never be taken except under strict medical supervision.

This is the case, for instance, with a dark red substance, called prontosil, which was perfected in 1935—experiments with this substance first started in Germany in 1911. From this substance is extracted a white powder, called sulphapyridine, which was first produced in Great Britain by May and Baker. This firm christened their product M & B 693 because it was the 693rd synthetic substance produced in the May and Baker laboratories.

M & B 693 belongs to a group of drugs, known as the sulphonamides, which have proved their value in the treatment of many bacterial diseases, notably certain types of pneumonia, gonorrheal infection of the eyes, and cerebrospinal meningitis.

Their chief disadvantage, however, is that the patient is sometimes liable to suffer from headaches, nausea and other signs of being poisoned. This is due to the mildly toxic effect of the sulphonamides on the germs which have invaded the patient. The germs do not appear to die a sudden death; instead, they are prevented from reproducing; so that the defences of the body have time to gather strength and destroy them.

Feats of Surgery

Modern technique has made possible many wonderful feats of surgery. A patient's heart has been taken out of the body, stitched, replaced and gently massaged into motion again. Dr. Walter Dandy in 1928 removed half the brain of each of five patients who were affected by rapidly growing tumours. One of these patients lived three and a half years; previously his case would have been hopeless. Lungs, one of the most dangerous organs to touch in the body, have been removed successfully. Diseased bone has been replaced by new bone, and the nerves and tissues induced to grow again.

Plastic Surgery

Among the many branches of surgical procedure which have become the "order of the day" during the twentieth century, perhaps that of plastic surgery is the most spectacular. Faces which have been burnt or injured, almost beyond recognition, have been repaired by this wonderful technique, certain congenital defects have been either hidden or removed, and artificial noses, eyes, ears and other parts have been grafted into position. It is impossible to describe the scope of plastic surgery in a few words or even to intimate the intricacies of a simple operation. The underlying principle, however, is the transplanting of healthy tissue from, say, the abdomen to the damaged or defective area, not infrequently the face. This is possible only after the damaged area has been built up or healed sufficiently to allow of this procedure. Thus, the plastic surgeon may sometimes have to wait weeks or even months before the damaged area is ready for plastic treatment.

Surgical Instruments

Mention must be made of the invaluable aid rendered by the anæsthetist, nurses and assistants at any major operation, but it is difficult to picture anything more marvellous in this world than the hands of a great surgeon.

Electricity has provided the sur-

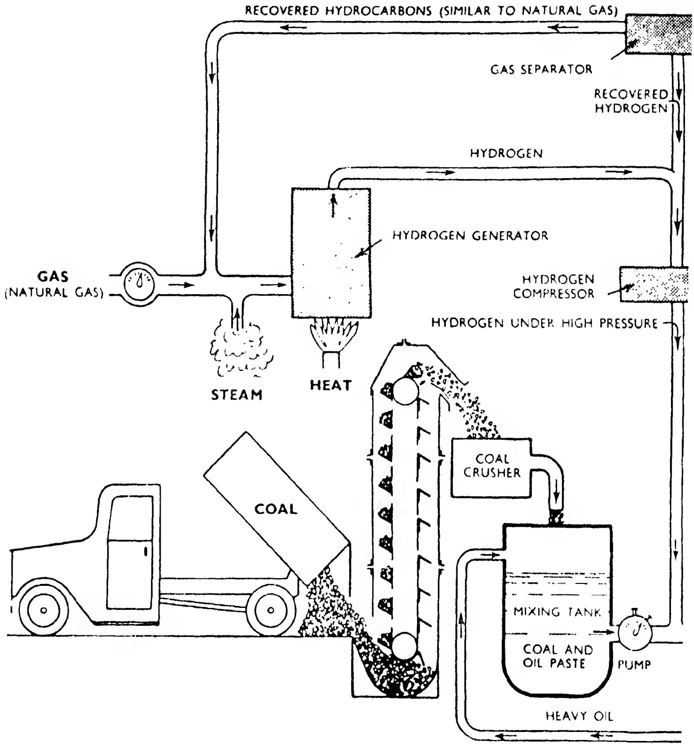
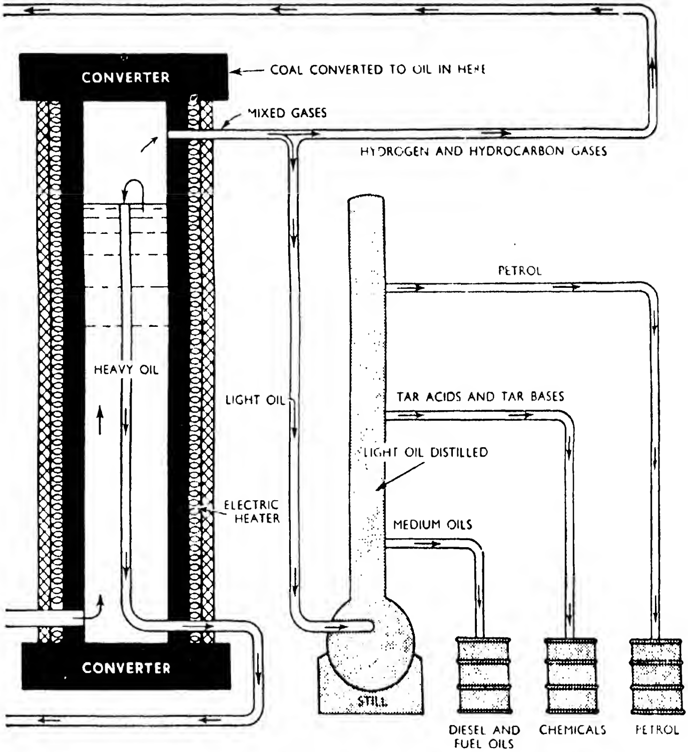


Fig. 19. *Simplified flow diagram of the United States Department of the Interior Bureau of Mines process for converting coal to oil by hydrogenation.*

geon with a remarkable aid. In 1906 Dr. Finley Cook invented an electric needle, for the purpose of burning away disease spots like infected tonsils, piles and similar minor ailments. Dr. Doyen, by increasing the power, succeeded in burning certain cancers. De Forest, of radio fame, then found that it was possible to make an electric current cut; but the "radio knife" was a good many years in obtaining recognition. Eventually, the American, Dr. G. A. Wyeth, made a very successful one in 1923. The radio knife reduces bleeding, and blunts the ends of nerves, so reducing the shock to the patient. The resulting wound is also germ-free; moreover, the radio knife can get at places which it would be dangerous if not impossible to approach with a surgeon's ordinary tools. Dr. Harvey Cushing, the eminent American brain specialist, found the "radio knife" of great



This method was begun in 1927; it takes one ton of coal and 48,000 cubic feet of hydrogen to produce, approximately, 170 gallons of motor spirit.

value in removing tumours of the brain (1928). The tumours could be shrunken until it was possible to withdraw them through a small hole in the skull. Internal tumours and cancer of the nose have also yielded to electro-surgery.

Industrial Achievements

The industrial achievements of the twentieth century, which are mainly due to great advances in organic chemistry, together with improvements in electrical engineering, form a long and impressive list. There is space to glance at but a few of the chief items. By reducing coal to powder and then forcing it to mix with hydrogen under great pressure, synthetic petroleum has been produced on a large scale, at first in Germany (1927), afterwards in Britain at the great Billingham plant, and in the United States of America (see Fig. 19). By a treatment of isoprene,

perbunan and other organic substances, not easy to describe in plain language, synthetic rubber is also made; this, too, is a development largely of the last few years, having been speeded up greatly during the war by the loss of the natural rubber plantations to Japan. The production of artificial silk or rayon, as it is now called, began in the early Victorian age, but it is during recent years only that it has advanced by leaps and bounds. Chemical treatment of resins and some other substances has produced plastics, a type of product for which a multitude of uses has already been found and which has a most promising future; it is only now really coming into its own. Geophysical surveying, which involves the use of delicate electrical apparatus, has replaced to some extent the geologist's old method of laboriously mapping a supposed oil-field, since it enables him to prophesy where oil is likely to occur, even though it is hidden beneath many hundreds of feet of rocks.

The diesel engine, which started as quite a small affair in 1898, has now developed into enormous units capable of driving a 27,000-ton liner, or providing power for the generators of a 1,400-ton train. The ordinary internal combustion engine has grown, just as astonishingly, from the erratic little engine of 1900 into the magnificent Rolls-Royce Merlin and Griffon, and the Napier Sabre, which have made possible the giant aircraft of today, with their enormous speeds and lifting power.

Delicate electrical instruments have been made to measure almost inconceivably minute units; there is even an electron microscope. On the other hand, by photo-electric cells it is possible to control to a nicety the movement of a giant swing bridge. At the dawn of the century men worked very often largely by rule of thumb; today this has given way to the rule of the instrument dial, such as the pyrometer, the thermostat, the wave-meter, and the spectroscope.

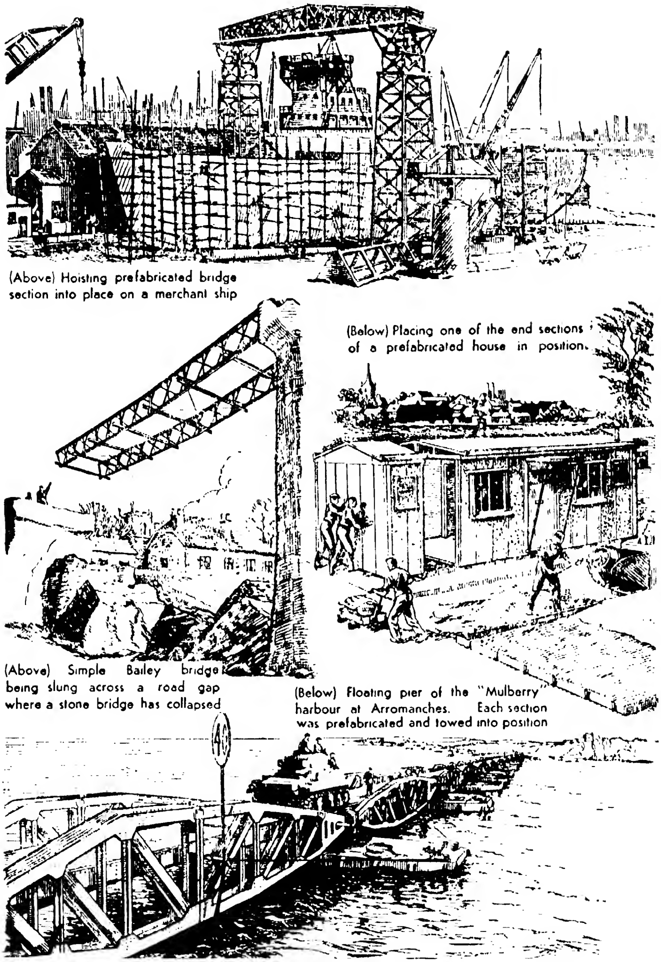
Metallurgical Advances

In the realm of metals, too, there have been enormous advances, hundreds of new alloys having been made and put to many important uses. Aluminium, for instance, has developed into the essential component of more than three hundred alloys, the uses of which range from aircraft parts to prefabricated houses. The range of copper and nickel alloys, stainless and other special steels has also expanded greatly in variety and importance.

It is now possible to extract huge quantities of copper from an ore which was formerly regarded as worthless stone. Invar, a nickel alloy which is highly resistant to temperature changes, is now the basis of Man's first really accurate measuring tape. The century has also provided such marvels as the one hundred inch giant telescope which was built at Mount Wilson towards the end of the First World War; a two hundred inch telescope is nearing completion.

Prefabrication

In civil engineering, Man has challenged nature as never before with such giant constructions as the Panama Canal, the Boulder Dam, and the draining of vast areas of the Zuider Zee. Prefabrication (see Fig. 20) marks another sign of the times, implying as it does



(Above) Hoisting prefabricated bridge section into place on a merchant ship

(Below) Placing one of the end sections of a prefabricated house in position.

(Above) Simple Bailey bridge being slung across a road gap where a stone bridge has collapsed

(Below) Floating pier of the "Mulberry" harbour at Arromanches. Each section was prefabricated and towed into position

Fig. 20. *Four examples of prefabrication. Shaped sections, usually of a uniform pattern, are manufactured at convenient centres and then transported to, and assembled on, the required site. Each section of the "Mulberry" harbour was manufactured in Britain, and towed to Arromanches where the complete harbour was assembled. The hollow piers were filled with sea water when positioned so that they sank and formed a firm base.*

mass production and a tendency to restriction of individual craftsmanship. One of the greatest triumphs of prefabrication, however, was the Arromanches harbour, which was towed across the English Channel during those wild, unforgettable days of early June, 1944.

Atomic Research

Earlier in this chapter, mention is made of the magical properties of a substance called radium. At the dawn of the twentieth century, the novelty and importance of this new substance immediately attracted the notice of many acute intellects, including Crookes, Ramsay, Rutherford and Soddy. The last two in particular proved that radium was not indestructible, although it would require 1,760 years to halve its bulk. It gave off a vapour, which was called the radium emanation (radon). Ramsay, who had a genius for handling minute quantities of matter, determined the density of a tiny quantity, no more than one-tenth of a cubic millimetre. To do this he had to weigh it in a very special balance, capable of turning with a load less than one-hundred thousandth of a milligramme; the counterweight was a bubble of air!

The successive breaking down of the radium residues produced a whole range of new substances, radium A, B, C, etc., ending in lead. Uranium, thorium and actinium, also broke down by stages.

Radium, however, gives off three distinct kinds of rays: alpha rays, which are particles of helium, beta rays or electrons, and gamma rays, which are light waves of very short wavelength. By bombarding the elements with alpha rays, Rutherford and others soon found that a good many of them could be broken up; besides bringing about the discovery of totally new substances, such as heavy water (deuterium), which showed that the so-called elements could actually be changed into one another. The atom, it became clear, was not indivisible at all, but was a composite thing, the particles of which when separated had all the chemical characters of quite different elements.

The Cyclotron

The heavier elements (except the very heaviest, uranium, etc., which decompose naturally), needed much greater power applied before the bonds holding their parts together could be broken, a power of several million volts. To produce such a power in a laboratory was not feasible until, in 1931, Lawrence, Sloan and Livingston invented a simple instrument for that purpose.

It was called a cyclotron, but America soon named it the atom-smasher (see Fig. 21). It has a central chamber, which is generally filled with hydrogen, helium or deuterium gas. A hot filament at the centre bombards this gas with high-speed electrons, thereby forcing it to yield protons (from hydrogen), alpha particles (from helium) or deuterons (from heavy water). These particles are the ammunition used in bombarding the more resistant atoms.

The principle of the cyclotron is interesting. The "ammunition particle" is made to circulate through two D-shaped boxes, which are connected to an alternating current supply of, say, one hundred thousand volts. The particle moves in the field of powerful magnets, which force it to travel in a circular path. When it jumps from the positive to the negative D its potential is

increased by one hundred thousand volts, and when after the half-circuit it jumps back again to the positive D it gains another hundred thousand volts, and so on; hence in one hundred jumps its potential will be the enormous amount of ten million volts.

By means of an electrode the particle is now drawn out of the D, and is shot through a small platinum window at the particular gas under examination. The marvellous result is that many substances which are far lighter and enormously more easy to procure than radium actually become artificially radioactive under the bombardment.

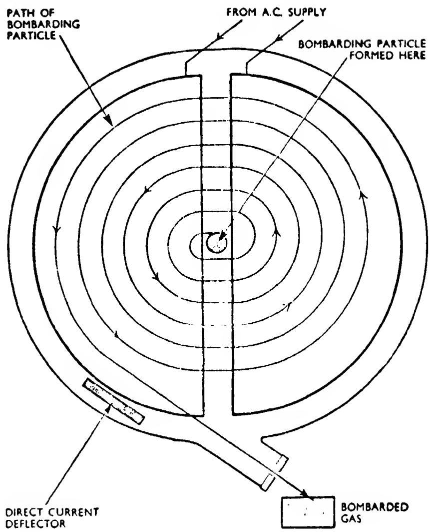


Fig. 21. *The cyclotron, or "atom-smasher." The bombarding particle circles through the D-shaped chambers and its potential is increased by the voltage applied to the chambers each time it leaps from D to D.*

Radioactive sodium has been produced in this way; and as the radioactivity of this common substance is effective for fifteen and a half hours, such sodium can be used to treat disease instead of the rare and costly radium.

The Atomic Bomb

One of the practical results of atomic research has been the terrible atomic bomb. Two relatively small bombs, one of which, at least, exploded in mid-air, are with credibility reported to have killed, wounded, or rendered homeless half a million people, and they brought a proud, obstinate, fanatical fighting race to its knees by the mere threat of more to follow.

Much that has appeared about the atomic bomb since those sensational flights over Hiroshima and Nagasaki in August, 1945, is true, and much is garbled or altogether false. The long statement issued by the Department of Scientific and Industrial Research sums up as much as the British Government deemed it wise to issue at that time. The public were told therein—what, of course, scientists have known for years—that if a quantity of radioactive gas could be made explosive, and then detonated, the results would equal the firing of many thousands of tons of T.N.T.

The element employed in the atomic bomb was an isotope of uranium, called U235 because that is its atomic weight. It was found

in 1939 that this substance was unstable, and in various countries, but particularly in Great Britain and the United States, the potentialities of the substance for destructive military purposes were realized almost at once. A second, and entirely new, substance called plutonium, very slightly heavier than uranium, was also found to have the same property; but, fortunately for Man, these unstable substances are all excessively rare and difficult to make.

In Britain a large committee, including many of the most distinguished physicists, was set to work, under the chairmanship of a cabinet minister, Sir John Anderson; much experimental work was done, and Imperial Chemical Industries undertook the preparation of the U235. But Britain was fighting for her life, she was peculiarly vulnerable to air attack, and the difficulties of preparing the raw material for the bomb were such as required more labour, time and plant than could be made available at the time. The project was then transferred to the United States, where it was carried to fruition, the larger part of the British team working there during the last two years of the war. Canada, which has considerable supplies of uranium ore, provided invaluable aid.

The problem, not unlike that of the commercial manufacture of penicillin, was to procure small quantities of final substance from enormous quantities of raw material; it cost a fabulous sum but it was done; and for this full credit must be given to the U.S.A.

The nature of the atomic bomb, though naturally a strict secret, has aroused the keenest curiosity. The official statement merely says that when the gas is compressed there comes a critical pressure above which it is liable to explode, but below which it is perfectly safe. It is possible therefore that the bomb contains two containers filled with U235 under pressure, so arranged that the contents of one can be automatically forced into the other, so as to raise its critical pressure. All that is then needed is a trigger to fire the thing. It must be remembered that the materials dealt with are not ordinary explosives at all, but that the action apparently depends upon a single neutron smashing an atom of U235 and thereby setting free other neutrons which, as they fly off, hit other atoms of U235 and so cause the explosive burst of energy.

The official statement says that the atoms are so unstable that neutrons of relatively low velocity will break them up. The "trigger" therefore may be a small quantity of heavy water in gaseous form, which is fired at by a small cyclotron that draws its power from a high tension battery within the bomb. This, of course, is a pure guess, but so have been all the other discussions of the bomb's nature.

It is now possible to reduce U235 and plutonium to substances which are suitable for the supply of atomic energy for industrial purposes. In announcing this development (March, 1946), the United States Under-Secretary of State said that the products would be unsuitable for atomic bombs.

We have seen some of the discoveries of the last half century. With the new forces now available Man may, if he will, go on to triumphs that will overshadow all the achievements of the past.

CHAPTER 11

ART OF THE WORLD

Prehistoric and primitive art. Influence of religion. Ancient Egypt. Sumeria, Assyria, and Babylon. Crete and Ancient Greece. The Greek orders. Greek influence on Roman art. Roman grandeur. Romanesque and Byzantine architecture. Art in the monasteries. Gothic architecture. Italian Renaissance. Baroque style. Dutch school. German art. Spanish painters. French school. Painting in England. The industrial age. Romanticism and Realism. Impressionism. Surrealism. Oriental art.

To a great many people art seems a subject entirely outside their normal sphere of thought, and when considered at all takes the shape of exhibits in some picture gallery or museum. But in reality art is part of our everyday experience. If, for instance, we stop to think of the architectural masterpieces of past generations that still surround us, we must realize that our life today is actually lived in a world of art.

This chapter is concerned with the visual arts only, which comprise painting, drawing, architecture and sculpture as the four mediums of expression. Not only has the world been greatly enriched by the beauty which her painters, sculptors and architects have created, but past civilizations have been recorded in brilliant and fascinating detail for all of us to see and enjoy.

Artists, whatever their medium from the earliest times, have been those people whose senses are especially acute in one way or another. Sometimes, as in the case of musicians, it is the sense of hearing that is keener and more aware of tones and tunes than ours; in just the same way the senses of sight and touch are especially acute in the artist who draws and paints or fashions things out of stone or wood. Not only does the artist satisfy his own desire to reproduce what he sees, but at the same time he does that which is far more important: he makes a vivid image which all can see and enjoy according to their own ability to appreciate his particular style.

Now the history of art is, in actual fact, as old as any record we have of civilization however elementary, because many thousands of years before there was any known method of writing we find cave-man drawings recording the doings of prehistoric Man and the animals that then populated the Earth, and these drawings are executed with a natural skill it would be hard to match today.

Just as soon as Man's evolution raised him above the beasts, the artist came into being. Every community must have boasted its artist for he was the man who, finding hunting, sleeping and eating did not entirely satisfy his needs, sought to express himself further by carving on the walls of his cave, or by drawing with charcoal or pieces of soil that carried some dye, or even by engraving the flat surface

of a bone with the sharp point of a stone or flint; and the pictures he made were all taken from the familiar scene around him (see Plates VA and VB).

The vitality of these early drawings shows that the movements of men and beasts attracted the artist more than the static representation of any other subject, and this same vitality seems to have inspired the truly primitive art in all parts of the world and in every age. Even today the works of the very primitive nomad tribes known as the bushmen of Africa, show the same desire to catch the instantaneous likeness of the startled or moving animal. There is nothing lifeless about these prehistoric and primitive artists' work.

Influence of Religion

One step further from the truly primitive brings us to those tribes whose art is chiefly concerned with religion of a primitive sort. They still exist and have as far as we know existed in much the same surroundings for long ages. Almost untouched by present civilization in other parts of the world, they are to be found mainly in Africa and Polynesia.

Such peoples were and still are greatly concerned with the worship of spirits, the ghosts of the departed or the imagined gods and goddesses who are believed to guard or destroy them and their property. From the earliest times the artists among these people have been concerned in producing awe-inspiring images to represent the gods they worship, or hideous figures which they think may look so terrible that the evil spirits will be frightened away from their district. This attitude of mind encouraged an entirely distinct type of art, still called primitive, but bearing no resemblance to that which has already been mentioned.

In the carving and painting of these images naturalistic or human tendencies play a minor part—the artist has been inspired with the idea to distort and exaggerate expressions and natural shapes, so that the finished work may appear the more awesome and grotesque. At the same time certain human resemblances are to be found so that the people for whom the drawings are intended can readily understand what qualities of good or evil their gods are supposed to possess. This type of art has conformed to very rigid conventions, but such qualities as balance of shapes, design and pattern have become instinctive features of the artist's work, and many of these images are outstanding for these qualities alone.

Thus primitive races give us solid figures hewn out of granite, stone or wood; weird heads, terrifying or inscrutable, distorted or exaggerated to give emphasis to the feature the artist wishes to be most impressive. Here we have the basic result of a religious interest which became an increasing motive of artistic inspiration as civilizations progressed.

As the ages rolled by, religion in some shape or form became the main interest in the life of Man. The desire to placate the gods with offerings of value to the giver gradually grew into the will to build places of worship and devise symbols of various sorts, thought to have an immediate connection with the gods themselves. Local artistic skill was employed by practically every community, and

Plate V (a) *One of the finest examples of caveman drawings is this life-like cow bison taken from the Altamira Caves. The dramatic vitality of primitive art is seen in this brilliant piece of observation. The animal is seen in a recumbent position suggested to the artist by a projection in the cave*

Plate V (b) *Another fine example of primitive art. In this instance, the lively bushman drawings are of rhebuck covering a giant eland. They were discovered and copied by Walter Battiss in Cape Province, South Africa*

Plate VI *This finely sculptured head of Queen Nefertiti—carved more than 1300 years B.C.—is a wonderful example of the artistic skill of Ancient Egypt. The eyes are made from rock crystal, the head is life size and carved from limestone, whilst the whole is painted in brilliant life-like colours.*

gradually the temple began to absorb the chief works of art of any particular race of people. We find that the king or ruler of these early peoples was frequently credited with a very close connection with the gods, and therefore to him also was given a beautiful palace enriched with the paintings and carvings of the most competent artists to be found. From such beginnings each and every generation contributed something to the world of art, handing on the skill and knowledge it had acquired until we come to the wonderful artistic achievements of the Egyptian civilization which was dawning before 4,000 B.C. (see Fig. 1).

Ancient Egypt

In ancient Egypt we can see the full scope of the visual arts for the first time in every detail; for archæological discoveries have made us familiar not only with the colossal works of these amazing people, but with the finest and smallest details of their wonderful craftsmen. Examples of architecture show us the magnificent proportions of their temples, with their finely sculptured columns. Their sculptors have left wonderfully lifelike figures of their kings and queens, and gods and goddesses, the head of Queen Nefertiti (see Plate VI) is a fine example of Egyptian sculpture in its most realistic phase. Their tombs have provided us with a wealth of information as to their furniture, wall-paintings and ornaments. The stylization and formality of Egyptian art remained grandly simple for the best part of four thousand years. Whether the artist used chisel or brush he invariably displayed great technical skill combined with a superb sense of design, and a genius for adapting all forms in nature to decorative purposes.

Practically all of us are familiar with the direct and simple work of the Egyptian artist: the flat forms made brilliant with clear bright colours, the heads turned in profile on square shoulders, the eyes drawn flatly as if seen from a frontal aspect, hands and feet stiffly formal though appropriate to the action portrayed. We are also familiar with the figures of their weird gods, half-human and half-animal.

Egyptian sculpture was of a firm beauty and balanced perfection of shapes and proportions built to endure. Sweeping lines carved with boldness of style and surety of aim have successfully defied the hand of time. The Sphinx and the Pyramids of Gizeh are ageless records of the Egyptian feeling for monumental forms. They are placed in relation and give emphasis to each other; the symmetry of the pyramids supporting the effect of timeless contemplation imparted by the Sphinx.

The pyramids themselves were the most stupendous engineering efforts in building ever undertaken by Man before the age of machinery, yet they were in reality only the tombs of kings. It is indeed from the tombs of Egypt that we have obtained our knowledge of the domestic art of the people, for it was the custom to furnish the last resting place of the dead with all the domestic and personal equipment that might be required in another life. Furniture of all sorts, cooking equipment, jewellery and vases of various types containing perfumes and oils have all been discovered in the tombs of the

kings, and the amazing mummy cases painted with lifelike portraits of the departed were placed within the highly decorated sarcophagi.

Egyptian Architecture

Simple grandeur was the keynote of architecture, particularly in the case of the temples, for however decorated and adorned inside there was no attempt to disguise or detract from the geometric simplicity of the whole. Usual features of their design were two gigantic pylons with a main doorway between which led into a colonnaded courtyard, the pylons being often decorated with a fine relief. Perhaps the most impressive Egyptian temple still in existence is the cave temple of Rameses II at Abu Simbel, for this is the perfect example of all that is most characteristic of the work of the Egyptian artist, sculptor and architect. Gigantic figures sixty-five feet high are hewn out of the solid rock, their formal simplicity a timeless tribute to the hands that carved them.

The columns in the interior of the Egyptian temples were lovely trunk-like pillars carved in finely curving lines, with beautifully shaped capitals designed either from the lotus flower or bud, or from the papyrus flower. These columns were always decorated with floral motifs, or with scenes from the lives of the gods or other heroic subjects. More often than not the base and capital formed the floral interest, whilst the centre of the column was decorated with figures. Colour was of primary interest and in the dry and naturally preservative climate of Egypt we find pigments of mineral dyes and paints which have suffered no discoloration in spite of the thousands of years that have rolled by since these were originally applied.

The wonderful clarity of colour obtained by the Egyptian artists can still be appreciated, for the atmosphere has done little to destroy the purity of these amazing mineral dyes. Lovely blues, greens, and turquoise shades are set off magnificently by the use of red ochre, yellow and the adept introduction of black and white. Similar colours are to be seen in the semi-precious stones and other materials that were employed so liberally in the jewellery of these people. Ivory, ebony and stones such as lapis lazuli, carnelian, felspar and turquoise, all set in gold, give an impression of great magnificence, and at the same time a beautiful harmony that is neither ostentatious nor crude. Other civilizations which flourished at approximately the same time as that of ancient Egypt have not left us such a rich legacy of artistic achievement, but what remains is sufficient to show that art played as important a part in their lives as it did in those of the Egyptians.

The Sumerian Technique

The culture of the Tigris-Euphrates Valley—which included the Sumerian, Assyrian and Babylonian civilizations during a period of four thousand years—was governed to a great extent by the complete lack of local wood or stone. Such materials had to be imported with great expense and difficulty. Brick and tiles, however, were readily available building materials, and consequently the workers, over a period of centuries, became magnificent craftsmen in these particular media.

The same local deficiency

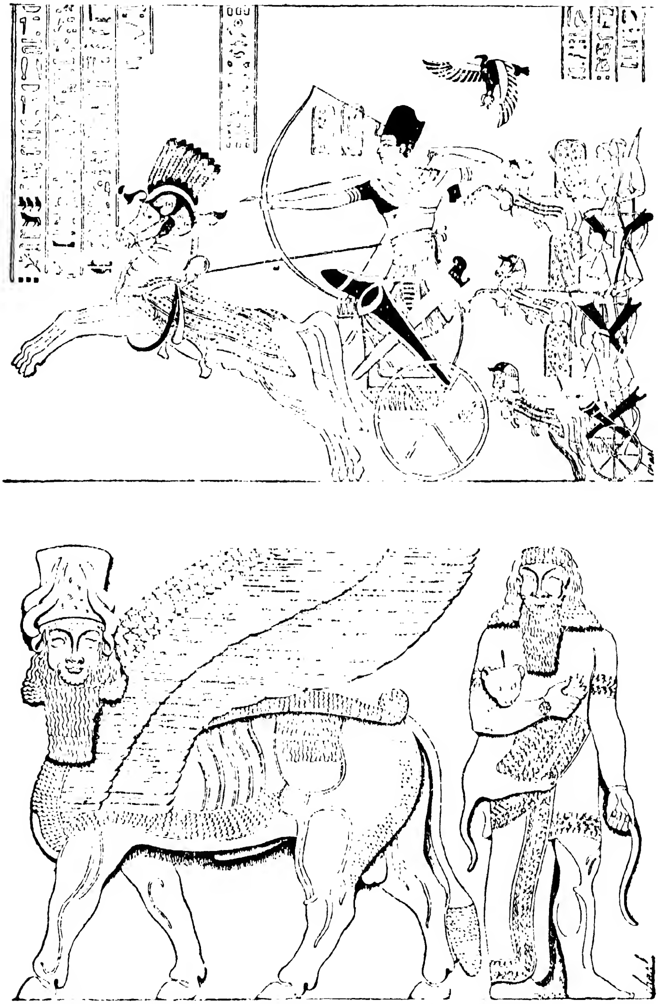


Fig. 1. *Two illustrations (specially drawn) to emphasize the characteristic difference between ancient Egyptian art (above) and Assyrian art (below). The sense of lightness and movement achieved by the Egyptians is portrayed in striking contrast to the impression of strength and solidity conveyed by the winged bull with human head which features in Assyrian art.*

accounts, to a great extent, for the comparatively small amount of large sculpture that can be attributed to these civilizations.

Where the occasion demanded grandeur of style on a large scale, the Sumerian architects or sculptors covered their carved brickwork with sheets of metal, so that a large polished surface was obtained. These surfaces were usually moulded into the shape of some animal or figure, and sometimes whole statues were produced in this manner. Metals of many sorts were employed, and decoration in copper, gold and silver served to emphasize the gay splendour of tiled halls and temples. Probably the best known symbol of these early races is the winged bull of Assyria, which was placed outside buildings to frighten away evil spirits in much the same manner as the primitive races, already referred to, still adopt an awesome figure outside their dwellings. The Assyrian bull with its human head, curled hair and beard is today as symbolical of the early Western Asiatic civilizations as the Sphinx is of Egypt (see Fig. 1).

Cretan Vitality

A comparatively short distance away from these rich centres of art and culture an entirely different civilization flourished from about 3,000 B.C. for two thousand years. This was in the Ægean Islands, and more particularly the island of Crete.

So far we have been concerned mostly with the art of peoples primarily interested in religion and king-deities; we have seen design governed to a great extent by the demands of religion, and a self-imposed formalization which was awe-inspiring to the beholder. Now, with the Cretan civilization a freer rendering of secular life makes its appearance in the world of art.

Thus, we see the growth of a new and keener form of observation which suggests that here was a full-blooded civilization in which the artist had begun to throw off the weight of convention. Bull-fights and acrobatic feats were vigorously painted on their walls in outlines full of movement. Stylization played a smaller part in the vivid and lively figures that took part in these sporting events. Pottery decoration also showed a new vivacity in both conception and treatment; local craftsmen took their ideas from the sea which surrounded them—fishes, seaweed and especially the Mediterranean squid frequently appear on pots and vases, all executed with a fine freedom and without monotonous repetition yet eminently suited to the shape of the article concerned.

One goddess appears to have been a favourite of these peoples—the Snake Goddess, of whom we find models in several museums today, usually depicted with arms outstretched, wearing a finely worked crown.

The pottery figures of Cretan women indicate a civilization of gay fashions, which wore patterned and embroidered clothes as brilliantly modelled as those created by a Paris dressmaker at the end of the nineteenth century.

Ancient Greece

From the art of Crete it is but a short step to that of ancient Greece, for our earliest knowledge of Greek art dates from approximately 1,000 B.C.

The Greek race was probably the outcome of a successful mingling

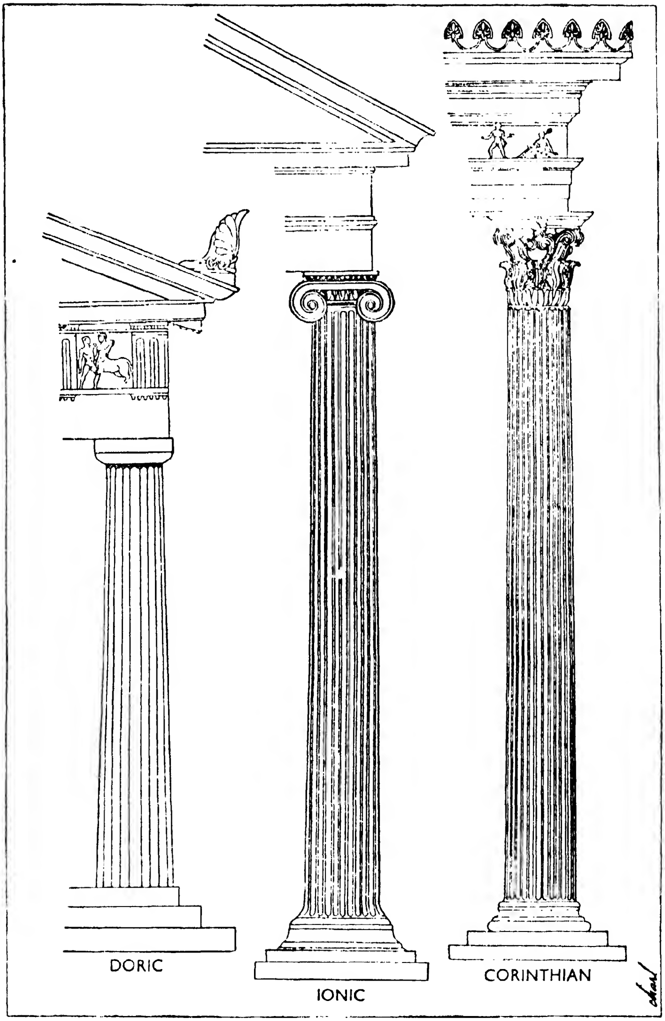


Fig. 2. *Three columns showing the characteristic features of the three Greek Orders of architecture. The Greek architects were controlled by very precise rules concerning the form and proportions of each detail of their work. The Romans adapted the Greek Orders for their use.*

of Indo-European invaders with other Mediterranean strains, and the Cretan influence must have still been fairly vital on the mainland at that date. Probably the strongest factor in the Greek culture was that of discipline—and discipline governed all forms of art with the ancient Greeks.

The Greek artist concerned himself with physical perfection. This aim made him especially attentive to human proportions. Every part of the human figure was worked out to accord with a certain canon of proportion; only within such limits was the artist permitted licence.

The Greek Orders

The Greek architecture was also governed by a coherent plan of form and proportions. The simplest way to explain such a discipline is to draw attention to the Greek Orders in which the form of the supporting columns was closely related to the style of architecture. Drawings of these three Orders explain in part the complicated but beautiful systems of proportion worked out by the ancient Greek architects. These three Orders, Doric, Ionic and Corinthian (see Fig. 2), have been a model for subsequent architects.

The best-known example of the Doric Order is the Parthenon which still stands on the Acropolis. The wall frieze and pediment, removed by Lord Elgin, are now to be seen at the British Museum. The Ionic Order with beautifully curved scroll capitals, is seen at its best in the Erechtheum, also on the Acropolis. The Corinthian Order was not used as much as the two simpler designs, but is very popular on modern buildings, and most of us are familiar with the lovely leaf of the acanthus plant which was used so decoratively as a capital to the slim ribbed columns outside both temple and theatre. The monument of Lysicrates in Athens is a delightful example of this Order.

Sculpture and Ornament

The ornament and design that decorated the classical works of sculpture and architecture was as formal as a naturalistic treatment of the human figure would allow, and we find that the treatment of animals, and particularly horses, often supplies the note of repetition, so valuable a commodity in all forms of design. It is particularly noticeable in the frieze from the Parthenon already mentioned.

Sculptured figures of gods and heroes have been found in abundance on the ancient sites of Greek temples and other important buildings, and from these figures with their refinement of line and detail, we can more easily realize the ultimate result of the discipline imposed on the artist. His sense of proportion and balance had become instinctive even before his skill as a finished artist was achieved.

The earlier types of sculpture of the Greek civilization are more formal and less realistic than those of the later period. The ideal of beauty was developed between the fifth and third centuries B.C. Hermes and the infant Dionysus by Praxiteles is an example. Such well-known statues as the Winged Victory at the Louvre, the Discobolos, and the Venus de Milo (Plate VII) are familiar products of later Greek naturalism.

Realism in ornament governed by the limits of the craft, and carried out on a two- or three-colour basis, characterizes the domestic pottery and minor arts of the

Greeks (see Fig. 3). The lovely draperies of the figures painted on vases are unequalled in any previously known form of art. Unfortunately, by the fourth century B.C., this fine type of ceramic art had almost ceased to exist.

Roman Grandeur

The art and history of Greece and Rome are linked not only by their geographical proximity, but by the overwhelming influence of Greek artistic ability. The energy of Rome was absorbed by her insatiable thirst for military conquest, and in her conquest of Greece she was impelled because of its artistic superiority to utilize and absorb the genius already inherent in Greek culture. The Greeks, who had been fundamentally concerned with the analysis and perfecting of everything related to art, were respected for this unusual quality by their Roman conquerers. To the Roman officers and officials who amassed a vast quantity of wealth, it became almost a social obligation to adorn their palaces with the rich spoils from the countries they had conquered.

At first homes and palaces were decorated with the beautifully sculptured figures that had been stripped from the Greek temples and houses, but as these became scarcer and the Roman appetite was still unsatisfied, Greek artists were imported to work in Italy and instruct artists of Roman birth. Finally, something of their natural inspiration was assimilated by the Roman pupils, and we find many examples of portrait sculpture that combine the warlike and aggressive vitality of the Romans with the technical skill of the Greek craftsman.

Fig. 3. *Greek pottery vase of the sixth century B.C., with enlarged reproduction of the design, showing the vigour and beauty of Greek vase painting.*

The same coarse vitality appears in Roman architecture. The engineering feats of this practical race are a permanent testimony to their scientific knowledge of structural principles. The Greek Orders too were adapted by the Romans, but a disregard of the originally prescribed and carefully balanced measurements caused the columns to lack the Greek refinement.

As engineering on a grand scale

there was nothing to compare with Roman architecture at its best, but it must be judged by its effect of grandeur and its practical utility, rather than in relation to the beautiful Greek work that formed the basis of some of its magnificence.

As the Roman Empire expanded, the desire for luxury and pleasure slowly became paramount. This is reflected in the many public baths and theatres. The examples of Roman architecture that still exist in Europe were originally the outcome of conquest, and the need for an effective system of communications and services such as aqueducts. Perhaps the most famous aqueduct of fine Roman workmanship still in almost perfect condition is that of the Pont du Gard in the south of France, and certainly the baths at Bath in Somerset are the finest existing record of the Roman occupation of Britain.

Decline of Roman Culture

The total lack of a true religious spirit in the Roman civilization did much to weaken its ideals in the realm of art. Everything created was for the benefit of the individual who footed the bill or supplied the labour, and as long as slave labour was both cheap and easily accessible the Romans continued to benefit by the craftsmen so easily supplied; as their power diminished so their achievements in the world of art became less and less. When at length they became an easy prey to the invading forces of Huns and Goths from the north, the Roman Empire had become a mere polished shell of culture and outward refinement. Her warlike vitality had died many generations before she was overrun by the barbarian races. The tradition of culture in Italy, however, fostered an interest in the arts among the new conquering hoards of Goths and Huns, and something of their cruder outlook and ability filtered into architecture and other works of art.

After the Romans

The architecture of the early Middle Ages is now called Romanesque (see Fig. 4). Ornate renderings of fabled monsters and grotesque men and beasts, together with the use of extremely simple geometrical designs, began to appear in ornament and eventually became a remarkable feature of medieval architecture. Christianity was the religion of the new occupants of Rome, but their extreme simplicity of outlook linked it with the strange mythologies of their northern gods. Centuries of confusion followed the passing of the Roman Empire. It was, therefore, a long time before a new influence was felt upon the rest of the now abandoned and leaderless countries in the rest of western Europe.

One other form of art should be mentioned here, the Byzantine (see Fig. 4). Whilst Rome tottered to her fall, one outstanding Roman Emperor made his appearance—this was Constantine. His ideals were good, and he himself became a Christian. In an already decayed civilization he made a grand struggle to divert the country from its headlong flight to destruction. In the early years of the fourth century A.D. he removed the capital of the Roman Empire to Byzantium, subsequently known as Constantinople, and nowadays as Istanbul. Detached from the decay of the original capital, a new form of art linked both with Roman

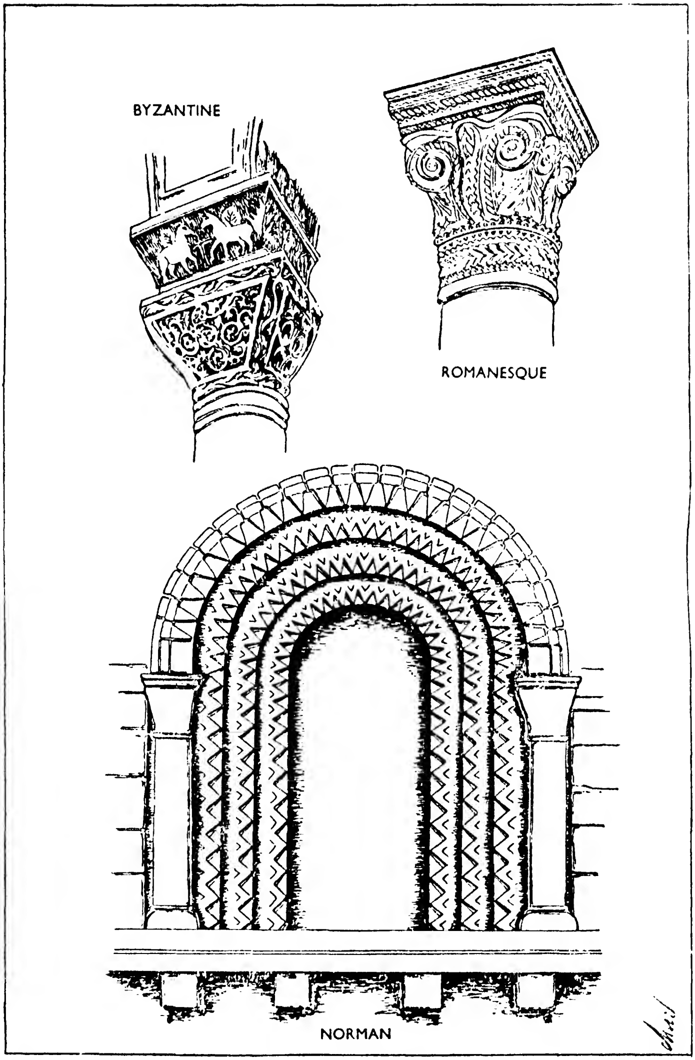


Fig. 4. *Examples of decoration used in medieval architecture. In Byzantium or Constantinople (now Istanbul) Eastern ideas were incorporated with the traditional Roman styles. Romanesque (which includes Norman) architecture used grotesque animal and plant forms, and simple designs.*

ideas and with eastern colour and ornament, but taking its motives from the Christian religion, made its ornate appearance. Its domes and decorated columns and its colourful glitter are still associated with the Eastern European Christian Churches.

With the final breakdown of the Roman Empire during the fourth century A.D., Europe entered the period now called the Dark Ages. Christianity was slowly filtering through the various countries, but religion gave little or nothing to the world of art at this particular date. The Church preached a hard creed, which demanded nothing less than a supreme renunciation of all worldly things in favour of a Heaven to come. The idea of erecting magnificent buildings was discouraged both by an endless and exhausting succession of wars, and by the austerity of religion. So depressing had the world become without decent rule and without settled culture, that the founding of monasteries wherein a man could escape from the problems of devastation and devote himself to prayer and meditation, uninterrupted by the lawless vagrants that swept all over the countryside in their search for food and loot, was eagerly welcomed. The monastic idea found adherents among those men who desired to escape the turmoil and lead a peaceful and cultured existence.

Art in the Monasteries

In the monastic life we see the dawn of a new desire for learning and the production of works of art. The four walls that protected the monks from outside interference, also induced the feeling of security so valuable to the work of every artist of whatever race or creed. So shattered and torn and dispersed had all traces of the previous civilizations become that, when eventually the Christian monks tried to produce illustrations and paintings or embroidered copes, their ideas were as far removed from the Greek ideal as it is possible to imagine. Once again the formal process of subordinating the human form to mystic symbols absorbed the attention of the monastic artist.

Among the many early monasteries founded in the Dark Ages, was that of St. Benedict in the sixth century. St. Benedict fostered the arts, and tried to encourage the monks who followed him to become craftsmen once again. Several monasteries were built which showed a considerable architectural ability and attention to detail. Many illuminated manuscripts also were produced (see Fig. 5), but for a period of about two hundred years there was very little spectacular artistic or architectural achievement to enrich the western side of Europe.

Christian Architecture

The Christian faith was gaining new ground at the close of the ninth century, and from this time on, until the beginnings of the Renaissance in Italy in the thirteenth century, the slow and steady progress in architecture took precedence over all forms of art. Most of us are familiar with many of the Romanesque and Gothic cathedrals and churches that still exist, not only in Britain but in France and other parts of western Europe.

The sculpture that formed part of their decoration was neither entirely

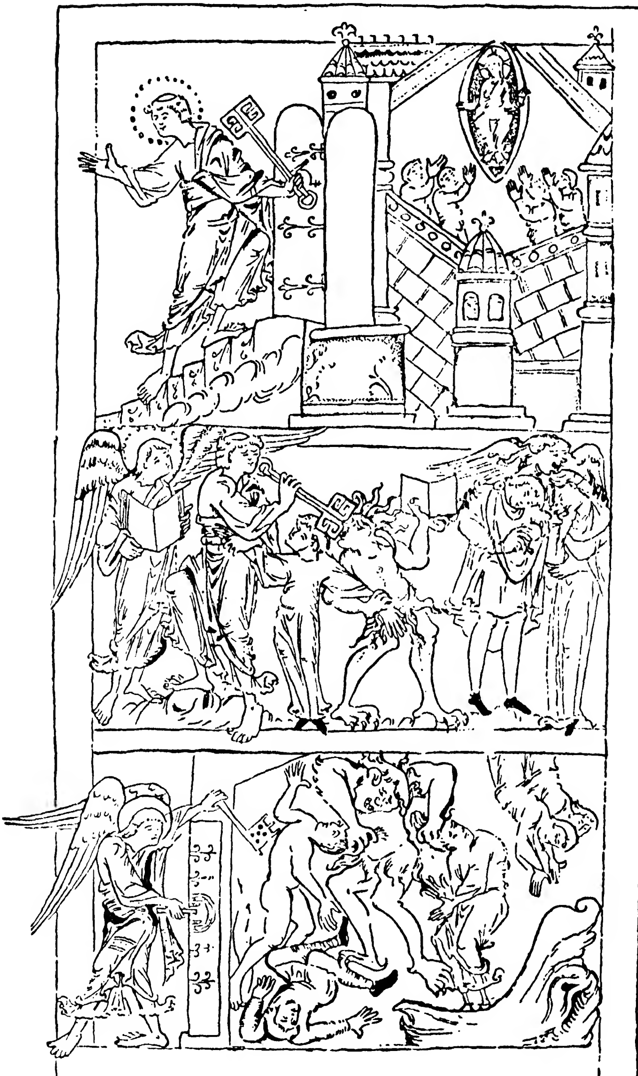


Fig. 5. *Reproduction after a page from the eleventh-century manuscript "Liber Vitae" of New Minster, Winchester. The original is a good example of the form of art fostered in the monasteries during the Middle Ages.*

formal nor entirely realistic. It combined the two qualities in a very distinctive way. Figure sculpture usually depicted scenes from the life of Christ or the Christian saints, and so it was not considered proper to take a living model, who was supposed to suffer from all the sins of the earthly world, as an example of saintly perfection. We, therefore, often find a fine head full of tragic or compassionate expression placed on a body which only crudely represents the natural human form. A common practice was to elongate the body out of all proportion, thus giving height to emphasize the dignity of the holy figure represented. This is particularly noticeable in the saints which decorate the doorway of Chartres Cathedral, built in the thirteenth century.

From the ninth to the fourteenth century, the period now called the Middle Ages, the same decorative trends persisted in most forms of figure representation. The folds of drapery and clothing played a very important part in design, and a curious mannerism persisted whereby the hands of a figure were depicted either with the fingers all spread out, or else with one or two of the fingers pointing.

The Gothic Period

There is no space in this survey to mention the many forms of architectural magnificence that found a place in the Middle Ages; the cathedral was the most important factor of communal life, and generations of men found occupation and education in the construction and decoration of these wonderful buildings.

The simple beauty of the Romanesque style, or Norman as it is more often called in England, gave place to more highly decorated Gothic styles in the thirteenth century. The most obvious difference in these two styles is the change over from the rounded arch, with its accompanying geometric designs and solid columns, to the pointed arch and vaulted ceilings with their more flowing lines and slender columns which gave a feeling of space and height, and suggested an entirely new form of decoration (see Fig. 6).

One of the best examples of Norman architecture in England still in an excellent condition is the Church of St. Bartholomew in Smithfield, London. Parts of Westminster Abbey, in London, such as those seen in Fig. 6, and Notre Dame Cathedral, in Paris, are wonderful examples of architecture at its best in the early Gothic style.

Italian Renaissance

Whilst such wonderful strides in architectural art were taking place all over western Europe, Italy once again felt the stirrings of a new cultural life. The arts had for some time been fostered by religious interest. Now lay patrons of the arts once more began to seek out artists and commission paintings on a grand scale to commemorate either themselves, or some deed of religious or national importance.

This period was called the Renaissance—the re-birth of classical knowledge and of the spirit of classical art. The period over which the Renaissance stretched was from, roughly, the middle of the thirteenth century to the middle of the seventeenth century. The work of the artists of the thirteenth century was still animated by the religious impetus which began in the Gothic

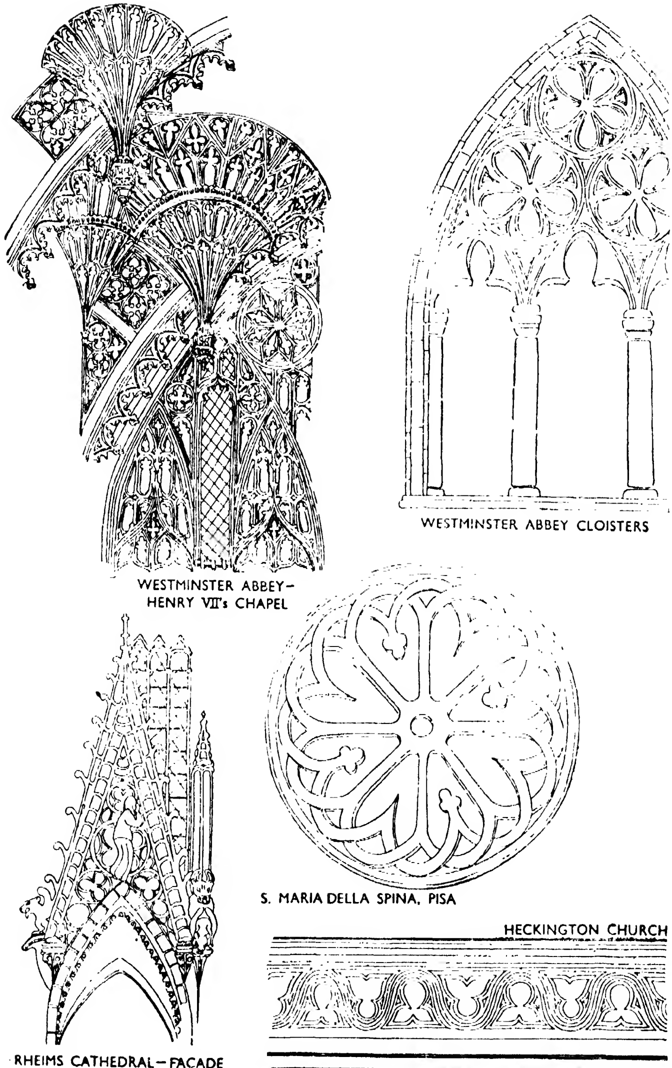


Fig. 6. *Examples of various styles of Gothic tracery. Note the "fan-tracery" in the roof of Henry VII's Chapel, a feature of the* **Perpendicular** *style of English Gothic architecture which also* **belongs** *to the* **Tudor Period.**

age, and during this time the outstanding artists were still influenced to a certain degree by accepted artistic conventions. However, the revival of interest in the art and letters of ancient Greece and Rome provoked a new desire for naturalism and a return to the classical outlook. The compelling charm of formal beauty combined with a true freshness of perception, which occurs in the works of the thirteenth- and fourteenth-century Italian artists is undoubtedly worthy of a special tribute.

The Florentine Giotto painted scenes from the lives of the saints with beautiful simplicity, and a purity of colour which has lasted in all its clarity to this day. Some of these paintings are still to be seen in Florence, the most famous being a series on St. Francis.

Fifteenth- and Sixteenth-Century Italian Art

The simplicity of the early Renaissance artists can always be admired, but it was in the fifteenth century that a new pictorial ability began to dazzle the world. Frescoes and other paintings of both religious and secular subjects bear the same richness of colour and harmonious composition. Many Italian city-states had their own schools of artists, and the sculptured figure now attained a perfection almost if not quite equal to that of the artists of ancient Greece.

In the fifteenth century such well-known artists as Botticelli (see Plate X), Uccello, Donatello, Benozzo Gozzoli, Pisanello (see Fig. 7), and Leonardo da Vinci (see Plate VIII), all in their different manners left the world a priceless heritage that was unknown when their work began. Technical mastery in painting and drawing, sculpture and architecture had once again been reached and it was left to the sixteenth-century artists to apply the technical skill thus achieved to the works of classical magnificence which decorated palace and cathedral.

Of these artists Michelangelo, Raphael, Giorgione, Titian, Correggio and Tintoretto are among the best known. Their work was varied, their subjects for the most part being either religious or taken from the classical mythologies, but

Fig. 7. *Study in black and white, after the Italian artist Pisanello.*

it was always technically skilful and beautiful in its natural and lifelike appeal. The true flesh tints, dramatic lighting, and an increasing interest in a natural background are characteristic features of the work of the Renaissance artists in Italy in the sixteenth century.

Renaissance Architecture

The Classical revival, as might be expected, revived an interest in the classic forms of architecture, and during the fourteenth century new buildings once more adopted the formality of the old Orders. They were enriched by the master works of the sculptors of the time. The architecture of the Renaissance owes some of its individuality to the sculptors and to a certain extent the painters. Gothic ornament was the product of a group of craftsmen —Renaissance ornament was part of a single scheme of design as conceived by the architect-sculptor. It is an interesting fact that art at this time had reached a stage of extended technical skill which enabled many artists to be architects, sculptors and painters at the same time. Of these Michelangelo (see Plate IX) is perhaps the most universal type.

Michelangelo (1475-1564) was a Florentine. His "David," and "Slave" are two of his best known sculptural works; the magnificent paintings on the wall and ceiling of the Sistine Chapel show his ability as a painter of remarkable genius. After completing them he became architect of St. Peter's.

The Baroque Style

The beginning of the seventeenth century marked the decline of the Renaissance in Italy. Ornament and design or decoration began to overbalance the classical foundation which had given rise to such a wonderful display of genius, and we now see the beginning of the style which is called baroque. Baroque art encouraged a florid and restless embellishment — an over-abundance of almost theatrical display that is now linked in our minds with fat cupids, florid women, cornucopias, exotic flowers, voluminous draperies and artificial postures. The ideal of Greek discipline had been forgotten or discarded in the extravagant indulgence of unrestrained melodramatic display.

Influence of Italian Artists

During the first century of the Italian Renaissance the rest of Europe, as we have already seen, was still limited to a considerable extent by the dictates of religious education—the only form of education available. Men were being trained in monasteries and cathedrals to devote their artistic endeavour to the glorification of God and the enrichment of the Church. The first natural and sincere simplicity of such art had begun to wear off, and a somewhat hidebound convention which was almost a formula of treatment was beginning to creep into all classes of pictorial representation, however exquisite the finished workmanship, or beautiful the design and colour.

The amazing prowess of the Italian artists must, however, have been remarked in every port or city where any form of foreign trade was being carried on, particularly so wherever Venetian, Florentine or Roman traders collected or disposed of their much prized merchandise. But so slow moving were things in those days,

and so unquestionably powerful was the Church and jealous of her established rights and rules, that it was not until the fourteenth century was well advanced that the first glimmerings of the Italian achievement were reflected in any other country.

The desire to travel and a new thirst for education seemed to stir the whole of western Europe during the fifteenth century. The introduction of the printing-press gave a new outlook to those who sought knowledge, yet previously had no access to the means of obtaining it. The fame of the Italian Renaissance had spread, and other countries sought to free themselves from the yoke of flamboyant decadence to which Gothic art had descended.

The various national schools of art that took shape during the fifteenth century, all swung back to the natural representation of the figure once again. This was the effect of the example given by Italy.

Dutch Painters

Each country developed on its own individual lines. The wonderful contribution made by the Netherlands to art began with the works of Jan Van Eyck in the early fifteenth century. A rich depth of colour and a minute attention to detail were achieved in these works. With the same hard gloss of paint that we see in the early Renaissance pictures he gave a microscopic attention to the finger nail, the reflection in a drop of water or the tear on an eyelash.

In Jan Van Eyck's painting of Arnolfini and his wife (in the National Gallery in London, see Plate XI), the reflection in the curved mirror behind the figures, is a fascinating detail that can be studied with infinite pleasure. This same delight in the detail of a gem or other sparkling point of interest, is a characteristic of the Dutch school, which reached its height in the seventeenth century, and few artists of other nationality have reached the same perfection of finish in domestic portrayal. Probably the best known Flemish artist of the sixteenth century was Pieter Bruegel. His love of peasant subjects and other scenes of everyday life gives us a vivid picture of his time and his country.

Dutch Simplicity

A simple homeliness is visible in the treatment and choice of subjects by the Dutch painters. It was they and their Flemish neighbours who started the fashion for flower painting and still life in groups. Details were brought into the foreground and assumed a new importance. The glossy surface of an apple vied in texture with the iridescent scales of a fish, a finely-cut wine glass or the sleek feathers of a bird. These artists were all primarily concerned with making a picture to hang on a wall that would add colour and light to the interior of a private house.

During the seventeenth century Frans Hals, Ter Borch, Vermeer and Pieter de Hooch enriched the world with their sparkling portraits and pictures of quiet interiors. They were true followers of the ideals of Dutch art. At approximately the same time, Rubens in Antwerp was producing large works based on the Italian baroque style. In them we can see the eventual fusion of northern and southern ideals in painting. Rembrandt, the most dramatic artist of his time, produced a multitude of vital

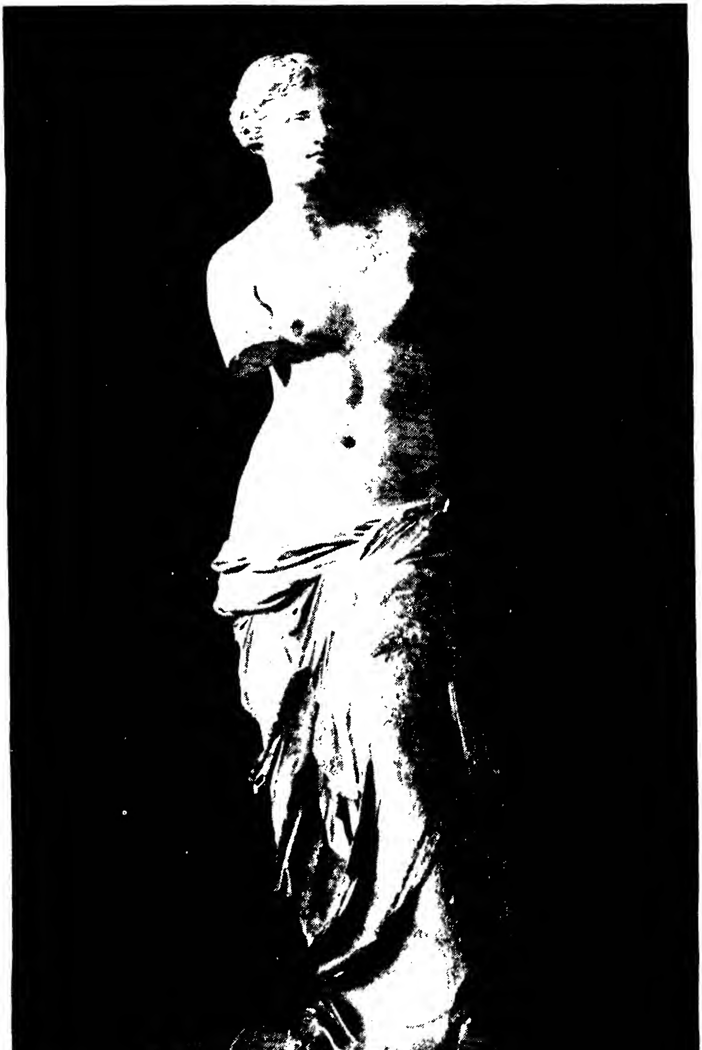


Plate VII. *"Venus de Milo," long accepted as the classical ideal of feminine proportions. The work was executed during the Hellenistic perioc.*

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Plate VIII *Leonardo da Vinci's most famous painting was this amazing portrait of Francesco del Giocondo's wife, Mona Lisa, now in the Louvre. The artist was born at Vinci in 1452 and his intellectual ability was evident at an early age. Ill fortune attended his works and few paintings by him survive, his Last Supper now being a mere ghost of the original, but his scientific drawings have been a subject of interest and speculation for centuries and show the extent of his careful examination of nature.*

Plate IX. *This unfinished painting by Michelangelo which is to be seen at the National Gallery in London—depicts the Madonna and Child, St. John and Angels. It was painted on wood in tempera about 1494 and was one of the artist's earliest works. Michelangelo Bumarroti was born in 1475 and died in 1564 after a lifetime crowded with work. Sculpture was the medium he preferred, and one of his masterpieces of sculpture was the colossal statue of David, formerly called "Apollo," carved out of a huge block of marble. The statue is now in the National Museum, Florence. His supreme achievement nevertheless is probably his great scheme of painted decorations for the Sistine Chapel Rome (1508-1512).*

Plate X. *Sandro Botticelli's world-famous "Birth of Venus" is a wonderful example of fine decorative treatment and delicate colouring. Botticelli was a pupil of the painter Filippo Leppi to whom he was apprenticed at about the age of fourteen. His "Birth of Venus" is in the Uffizi Gallery, and ranks with his equally well known "Primavera" (in the Florentine Academy) as one of the great achievements of Italian art. His youthful fondness for classical subjects gave way to a religious bent. He was much*

impressed by the stern teachings of Savonarola, and in later years illustrated Dante. Particularly is this quality to be observed in the artist's skilful treatment and arrangements of hair; the delicate insistence of small pattern and the singularly "cut-out" appearance of foliage. His interest in pagan legend was eminently suited to this particular style. Botticelli was, unlike many great artists of his time (1440-1510), hailed as a genius by his own generation. "Mars and Venus," is another of his masterpieces.

Plate XI. *The wonderful skill of Jan Van Eyck, his brilliant colours and his absorbing interest in each glittering detail, can all be seen in the original of this lovely painting of Jan Arnolfini and his wife (National Gallery). The painting is signed above the mirror in the background "Johannes de Eyck fuit hic" with the date 1434. Painting at the beginning of the 15th century Jan Van Eyck and his brother Hubert are classical masters of early Flemish art. Their work is a landmark in the history of art not only for its finish but also because they first perfected the technique of oil painting.*

Plate XII. *Velasquez's sympathetic and arresting painting of the little Infanta Margaretta of Spain gives an intimate peep into court life. This picture, called "Las Meninas" or "The Maids of Honour," is in the Prado, Madrid. Note: the artist has included a portrait of himself at work.*

Plate XIII. *John Constable's brilliant interpretation of nature in her most sparkling mood, can be seen in this well-known painting of "The Cornfield." The early landscape painters had been tied by convention: their landscapes were scenic backgrounds rather than pictures from nature. At last, with Turner and Constable at the beginning of the nineteenth century, painting began to be freed from the atmosphere of the studio. Both of them insisted on truth of observation and made a close study of the actual effects of light which painters hitherto had disregarded. The landscape of England in its changing atmospheric effects lent itself to this medium. The French Impressionists were aided in their study of nature by Constable and Turner.*

paintings, drawings and etchings all full of life and dramatic emphasis. His vivid imagination was combined with superlative craftsmanship. We are indeed fortunate that so many of his works are still in existence. The so-called "Night Watch" in the Rijksmuseum, Amsterdam, is perhaps one of his most stirring works, but his slight, free drawings are all well worth careful study (see Figs. 8 and 9).

German Artists

Art in Germany was given impetus by religious conviction, but it was also inspired by the warlike and harsh temperament characteristic of the race. German artists depicted the agonies of the Crucifixion and the tortures of the martyred saints with violence and realism, on stained-glass windows and ornately carved altarpieces. With the progress of the printing-press in the fifteenth century, illustration by woodcuts started a new interest in graphic art, and the German artists showed great aptitude for this type of work, in which craftsmanship and a sense of decorative outline went together.

Albrecht Dürer (1471-1528) was the first of these artists to gain European esteem with his vivid interpretations of the Gospels. His illustrations included line engraving and woodcuts, and the technical skill of the artist was enhanced by his sincere convictions and imaginative power. His detail drawings are some of the most complete and perfect miniatures we have. Even the smallest insect appearing in one of his finished works was drawn with delicate skill and intricate linear perfection. Of such drawings the beetle and the hare, studies for his painting of the "Adoration of the Kings" are excellent examples.

Hans Holbein (1497-1543) was also inspired by the possibilities of woodcutting and engraving, and his illustrations for "The Dance of Death" (see Figs. 10A and 10B, page 436) show a remarkable dramatic power. It was in England, however, that his work reached its highest peak. As court painter to Henry VIII, he produced a magnificent series of portraits of the famous people of the age (see Fig. 11, pages 438-439). His fine drawing and appreciation of the pictorial possibilities of dress of the time added interest over and above that of the personalities he succeeded in transferring to canvas.

Lucas Cranach (of Saxony), who flourished at approximately the same time as Holbein, shows the type of realism so typical of his country. His figures all bear the stamp of the Middle Ages, and particularly is this noticeable in the nude figures which he introduced into such symbolic subject pictures as "Charity," or "Jealousy."

After the sixteenth century art died in Germany, owing to the devastation of religious wars.

Spanish Artists

Spain, owing to the mountain barrier on her northern frontiers and her close interconnection with Africa, was more influenced by Moorish forms of art than any other European country during the period of the Italian Renaissance.

During the sixteenth century, El Greco, a Cretan by birth, was inspired by the intensely religious atmosphere of Spain at that time. After some time in Venice, where he was influenced by Tintoretto, he made his home in Toledo and

dedicated his life to painting religious subjects. His work shows an emotional intensity, and a strength of light and strange colouring that reflects the fanatical religious fervour of the Spanish Inquisition. However, Velazquez (1599-1660) was the first true Spanish painter, who, following the ideals of naturalism rather than those of religious mysticism, produced great portraits and paintings spacious in composition and arrangement. His extraordinarily clever rendering of light gave strength and depth to all his works. One of the best known of his masterly group compositions is the "Maids of Honour" at the Prado in Madrid, in which we see the painter at work, painting the little Infanta (see Plate XII).

Fig. 8. *"Head of Saskia," from an etching by Rembrandt, who produced with infinite care several other lovingly executed portraits of his wife.*

The only other artist of great note during the seventeenth century in Spain was Murillo. His works were all religious in subject, and the delicate charm of his madonnas and angels echoed something of the qualities found in the Italian painters of the time. Towards the end of the eighteenth century, a Spanish painter called Goya set the world agog with his brilliant portraits and satires. Not only are his works of superlative draughtsmanship but he has succeeded in evoking the political atmosphere of his age, especially the bitterness and tragedy of war. His portraits are extraordinarily alive, whilst his drawings and prints are executed with a biting significance and brilliant draughtsmanship.

The French School

In France curiously enough, in spite of her proximity to Italy, there was no vital school of painting before the sixteenth century. Miniature painting had reached a high standard of proficiency, and a few excellent portraits were produced but little or nothing to be compared with the grand canvases of the Renaissance. Two brothers in the early years of the sixteenth century produced paintings of popular interest and peasant life which are nearer in feeling to the Dutch styles. These were Antoine and Mathieu Le Nain. Although the first three centuries of Italian Renaissance art had already passed almost unnoticed by French painters, the grandiose baroque style was welcomed and encouraged in Louis XIV's time, and its swirling forms seemed particularly well suited to the luxury and power of this centralized government. Decoration without restraint either in cost or style was applied to the royal palaces and the chateaux of nobles. The Palace of Versailles is a wonderful example of grandeur in the exuberant style favoured by Louis XIV. Furniture and tapestries, wall decoration and painting were all produced in this style to match the baroque architecture.

During the seventeenth century painting reached a high standard of

Fig. 9. *A charming study by the Dutch artist Rembrandt Harmensz Van Rijn (1606-1669) which reveals the artist's outstanding ability to catch the form and character of the subject even in the simplest sketch. Rembrandt produced many drawings in pen and wash, besides great numbers of etchings, but it is upon his magnificent paintings that his fame chiefly rests. Landscapes, portraits, still life, biblical subjects were executed with equal facility and craftsmanship. For many years the foremost portrait painter in Amsterdam, Rembrandt also produced likenesses of himself and his family.*

Fig. 10 (a). *"The Duchess," one of a series of woodcuts designed by Hans Holbein to illustrate "The Dance of Death."*

distinction. French artists applied their skill to classical and mythological subjects with a landscape setting which produced a new element of artistic interest. Poussin and Claude Lorrain were perhaps the most famous of the artists in this vein during the seventeenth century, and many of their landscapes are exceptionally beautiful. A spirit of light-hearted gaiety is particularly associated with the eighteenth-century French painters such as Boucher, Fragonard, Lancret and Watteau. Their paintings deal delicately and playfully with frivolous and amorous adventure, thus reflecting the superficiality of the French court. Nevertheless, they are rich in charm and colour and reveal a technique of considerable merit.

One other artist of the mid-eighteenth century whose work did not follow the prevalent fashion but was akin to that of the Dutch school, was Chardin. His beautiful still life groups and charming domestic scenes of French middle class life, such as "Saying Grace" in the Louvre, will always attract attention with their sober realism and restraint of colour. Towards the end of the eighteenth century we find such painters as Greuze and Vigée Le Brun, both interested in the domestic scene.

English Architects

In England it was not until the eighteenth century that a national school of painting came into prominence.

Court painters for centuries had been imported. Holbein, at the court of Henry VIII, was of German birth; Van Dyck, a pupil of Rubens, was a Fleming; Sir Peter Lely, court painter to Charles II, was Dutch. Architecture, however, for

Fig. 10 (b). *"The Nun," another of Holbein's fifty-eight woodcuts for "The Dance of Death."*

both religious and secular purposes was actively studied throughout Great Britain. The Englishman was primarily a craftsman. Although the Renaissance had made little or no impression in England, as far as picture painting was concerned, architecture made giant strides under the guidance of such well-known architects as Inigo Jones and Christopher Wren during the seventeenth century. Their skill and learning made the classical formula capable of varied adaptations and following them the eighteenth-century architects produced buildings of great taste and excellent proportion. The Adam brothers, working during the latter half of the eighteenth century, produced many such buildings; Sion House, Isleworth, Ken Wood House, Hampstead, and the old Adelphi are a few examples.

English Painters

William Hogarth (1697-1764), was the first truly English painter of outstanding ability. His series, "Marriage à la Mode" and "The Rake's Progress," are familiar in black and white to most of us, but the beauty and vivacity of the "Marriage à la Mode" series in the Tate Gallery, London, is well worth considerable attention. Not only was Hogarth a moralist who exposed the vices of the age in which he lived, but he was a painter of extraordinary powers; there is life and sparkle in the least of his subjects, expression leapt from his brush however small the canvas he had to cover, and his portrait painting is both delicate and skilful.

Portraiture reached a high standard of perfection during the eighteenth century, and especially the family portrait and groups of figures or conversation pieces as they were called. Of the artists thus employed, Zoffany is probably the best known. His charming wigged figures in silks and satins reflect the stately composure of the period. Of such paintings, the "Water Picnic" is a perfect commentary on the tastes and habits of his time. Gainsborough, Raeburn, Reynolds, Romney and Lawrence were all skilled painters who produced distinguished portraits of eighteenth-century people.

The closing years of the century witnessed a new interest in landscape painting and water-colours. Amongst these early water-colourists Rowlandson struck out a new line in his lively commentaries on the pursuits and amusements of his day. With the lightest of treatment in line and wash he has left us a rich selection of pictures, vividly recording eighteenth-century life in town and country.

Other English painters of the closing years of the eighteenth century and the beginning of the nineteenth, concentrated on landscape. Technically skilled in both oil and water-colour painting, they made a great contribution not only to British art, but to the whole development of painting. Of them, Wilson, Crome, Constable (see Plate XIII) and Turner are the best known, and a great number of their works are to be seen in the national collections of Britain.

The Industrial Age

With the industrial revolution, and the introduction of photography, the world of art tottered on its ancient foundations. New ideas and experiments grew apace in western civilization with a stimulating effect on the sensitive

Fig. 11. *A study prepared by the German artist Hans Holbein for a group portrait of Sir Thomas More and his family. Copies still in existenc show that the projected portrait was completed, but the original has bee*

lost. The artist lived in England for a number of years and portrayed many of the famous personalities of the time, including Henry VIII and his family. Holbein died in London after an attack of the plague in 1543.

minds of the artists of the nineteenth century. We can safely say that the latter half of the nineteenth century saw the beginning of modern art.

The coming of the Industrial Age gave many forms of art a staggering blow. Mass produced and machine-made goods deprived the handicraftsman of his economic status—his work was redundant in a market packed with cheap machine-made wares and imported cheaper foreign goods. Painters, too, found themselves faced with new problems; for not only did many of them find the growing noise and turmoil uncongenial, but their market was a very different one from that of the eighteenth-century artist. Commerce and industry had raised a new type of patron who was no longer cultured and versed in the appreciation of art and music. These patrons, fresh from the mill or factory, lacked the form of upbringing which made the understanding patron. Even the portrait painter found himself challenged for his livelihood by the introduction of photography in the 'forties.

Romanticism

During the first quarter of the nineteenth century the landscape painter found solace from the growing menace of machinery in his choice of romantic landscape subjects. Romanticism began to creep into the work of most artists, and took other forms. Oriental adventure, romantic legend and romantic episodes of history became popular subjects. The Western world was cloyed in a few years with a veritable hotchpotch of historical inaccuracies. Architecture, sculpture and painting suffered alike from a romanticized edition of the medieval models to which the new age turned. Turner represents the Romantic spirit in landscape, Delacroix in figure compositions.

The Impressionists

It was in France that the next dramatic movement in the world of art took place. This was known at first as Realism, in defiance of the imaginative inclinations of the Romantics. A kindred reaction in England was Pre-Raphaelitism with its dogma of "Truth to Nature." Realism demanded the acceptance of contemporary life in all its actuality even when it was sordid or commonplace. The French artist who led the way in this new phase was Courbet. Art had been wrapped in the cotton-wool of convention long enough to encourage a new boldness of outlook and treatment. Subject matter was no longer the first thought of the artist, his main desire in painting was to express what he saw without idealizing anything. There is no denying the freshness and vitality of the paintings that were executed on these principles. In the generation after Courbet, Manet, Monet, Renoir, and Degas (see Plate XIV), all produced pictures of contemporary life with a skill and individuality of perception that earned for them the scathing title of Impressionists. Their work was not to the public taste and was long despised in France; in England it also met with opposition and was even slower to be appreciated.

Post-Impressionism

The Impressionists had, however, started a sincere movement, which in time successfully broke the

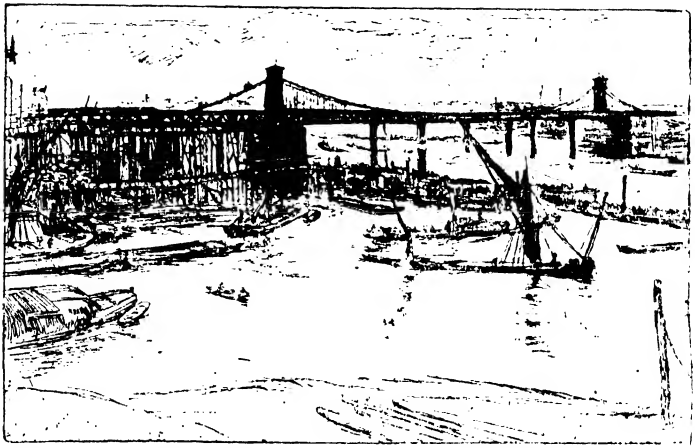


Fig. 12. *"Old Hungerford Bridge": an impression by Whistler of one of his favourite river scenes. Whistler, an American by birth, was famous not only for his paintings—some of which provoked bitter controversy—but for his etchings, especially the series devoted to London and Venice.*

shackles of nineteenth-century sentimentality. Other artists who were followers of the original principles of the Impressionists, went further, and began to analyse the effect and relation of colours even more closely. Amongst these we find Seurat, who painted in dots of pure colour to obtain the atmosphere of reality. Van Gogh and Gauguin, both influenced by the Impressionists, produced startlingly colourful paintings with a bold brilliance that caused even more debate than those of Manet. These artists have since been called Post-Impressionists.

One of the most criticized artists of the late nineteenth century in England, was James McNeill Whistler. An ardent admirer of the great French artists of his time, he was inspired, as to some extent they were, by the work of the Japanese. Whistler created an individual art, applying the restraint and carefully considered design of Japanese colour prints to Western themes. His famous portraits of his mother and of Carlyle are particularly good examples of the principle on which he worked, although his pictures of the Thames, which he called nocturnes, are perhaps equally famous. A black-and-white drawing on the same theme is shown in Fig. 12.

The Edwardian Artists

The first decade of the twentieth century, and indeed, the years up to the outbreak of the First World War, were a period of peace and plenty which has seldom been equalled in the history of Europe. A comfortable, almost smug, security had settled into the hearts and minds of that temporarily fortunate generation. Science had made life easier, more comfortable

and more exciting; the motor car, the cinema, electricity and gas were all contributing to the feeling of luxurious comfort and achievement. The first problems of a mechanized world had been successfully negotiated without as yet reaching the terrifyingly destructive possibilities of scientific invention which were to shake the world in the coming years.

For a short space of time the civilized world could quietly contemplate the wonderful progress of Man, and his apparently successful taming of the elements to his personal benefit and progress.

During this period, several gifted artists came into a position of prominence; amongst fashionable portrait painters Sargent was perhaps the most popular. Painting the wealthy Edwardian beauties and American heiresses, he succeeded in producing a brilliant collection of portraits that were at once considered daring yet pleasing to the sitters. His skill was particularly suited to the rich and worthy complacency of that glittering and comfortable age.

On the other hand there were at this time a considerable number of artists who took their inspiration from the Paris schools; in England there were artists who were neither quite French in thought nor altogether English. Of these Sickert was one. He sought out subjects that, if not actually showing the seamy side of life, gave a vivid impression of the dingy quarters of London and the popular entertainment of the music hall. At this time many of the best English painters were members of the New English Art Club, founded to develop the ideals of French Impressionism. The primary function of such a club was to clear the congested atmosphere of the dreamy sentiment which had clogged all true vision during the nineteenth century, particularly in England. Augustus John is one of the New English Art Club's most distinguished early members still living.

Pictorial Advertising

During this period of experiment in art the world had slowly become more and more aware of the needs and demands of commerce and industry, and a new field of artistic endeavour had opened up for the artist both in pictorial advertising and poster design. Obviously these requirements had to be met with some new method of attracting the eye, and posters of various sorts began to be reproduced from famous paintings. The first of these was the painting of "Bubbles" by Millais, which was bought by the proprietors of Pears' soap after being hung in the Academy, and achieved fame as a poster.

This change-over from the accepted idea that an artist's work was designed principally for purposes of interior decoration to that of an arresting poster which had to attract the eye of the man in the street, even if he had no knowledge or appreciation of art, created a false and hesitant approach to the subject. Early posters were mostly rather coarse enlargements of paintings executed with a minimum of detail and often crude in colouring. The established artist was slow to accept orders for work of this sort that might be to the detriment of his established position.

Poster work, therefore, was taken up as a new career by young artists. What had started simply as a pictorial method of advertising

gradually began to take form as a method of attracting the public's notice by visual shock-tactics. With an ever increasing range of goods to be advertised, competition in startling effects led the poster artist into an amazing variety of forms of mass-hypnotism — their primary desire to compel the eye rather than attract the senses. Experiment and industry together have caused a positive volcano to erupt in the world of art, from whose flame and smoke we have not yet emerged.

Book Illustrations

Illustration, which had for many years been carried out by engravings and wood-cuts, had reached a very high standard of artistic endeavour in the nineteenth century. Such artists as Daumier, Cruikshank, Tenniel, du Maurier, Leech and a score of others have left us a rich store of delightful illustrations of their time, skilfully drawn and full of incidents of contemporary life. With the discovery of photographic reproduction a variety of new processes gave zest to the previously limited technique of book illustration. Illustrations could now be carried out in both colour and wash as well as line. Illustrated magazines began to appear in a considerable number, and a growing demand for suitable illustrations encouraged the artists to study the limitations of reproduction and produce pictures whose quality was adapted to the process to be used.

Many charming colour books for children were produced during the latter half of the nineteenth century. Walter Crane and Kate Greenaway may be mentioned as outstanding in this field. Their example was followed by many other artists.

Amongst those artists who preferred to work in black and white Aubrey Beardsley at the end of the nineteenth century created an entirely new mode of decorative illustration, both erotic and romantic, reflecting for a few years the emotional crisis through which art had just struggled. The expanding field of book illustration during the present century has encouraged all forms of drawing and painting, and artists can now find a market in the field of reproduction for their works in pastel, oil, water-colour and monochrome which lose no quality in the process.

As we have already seen, the nineteenth century surpassed all its predecessors in its scientific and mechanical discoveries. The dizzy pace of such scientific progress has unbalanced and distorted for a time the proportionate values of the arts and sciences, so that at present more attention is lavished on engineering and mechanical perfection than on those qualities of the arts which have in the past flavoured and coloured the everyday world in which we live.

Modern Architecture

The thought in architecture has turned from dignity to utility. Domestic efficiency became the keynote of architectural endeavour, and after the romantic Gothic of the nineteenth century and other revivals, the tendency to make buildings purely functional was carried to extremes in the typical modern blocks of flats and commercial and industrial buildings.

These have been carried out on a large scale and on steel frame structures, with a thin wall covering to give complete economy in space. Generally speaking, architecture has become a complicated and

efficient feat of engineering skill rather than an artistic accomplishment, and as such there is much to be admired in the sure smooth soaring lines of a skyscraper, or the well-sprung efficiency of a modern concrete bridge.

The Skyscraper

If we stop to consider the amazing feats of engineering skill that have gone into the building of the American and Canadian skyscrapers, that carry anything up to a hundred floors, it is impossible not to be impressed. This is the architecture peculiar to the age, for without the electric lift and steel construction such buildings could never have been erected. It still remains a matter of speculation whether this form of architecture is to be considered an artistic achievement, but New York's skyline must be counted one of the wonders of the modern world, and the Empire State Building one of its most wonderful single efforts in architecture.

Amongst modern achievements in industrial architecture we find many buildings whose character depends on fitness to their particular practical purpose. Of these, Battersea power station is a particularly good example, for few people could fail to be immediately impressed by the sense of strength and power imparted by the colossal chimneys and solid foundations of one of southern England's main sources of electric power.

Domestic Architecture

In domestic buildings also, the main idea to be considered has been the changing demands of a new social order. In the past, large, dignified and imposing houses absorbed the large supply available of servant labour, and could be maintained with a sufficiency of both indoor and outdoor staff. Now the factory and office offer a new life for all those in and about the towns and cities. With the closing of many large houses, now uneconomic to manage, the demand for the small flat and cheap house became large and constant.

Blocks of flats have been built under the supervision of an engineer rather than of an architect, and the results are not as happy as they might be, if more time and thought had gone into their general external effect, rather than the labyrinth of partitions that goes to make up the homes of the world's workers. Utility and the saving of space have been primary considerations of the architect, and kitchens and bathrooms have become principal features of the modern flat.

The Country House

One of the most serviceable of all architectural developments in the twentieth century has been the country house based on Georgian principles, and carried out with a minimum of ornament. This type of building is particularly suited to the English country, and British architects have produced a considerable number of houses of solid worth and artistic value deriving from a national tradition. Sir Edwin Lutyens and Sir Guy Dawber succeeded in re-establishing a traditional style without loss of quality in so doing. Lutyens not only designed numerous country houses, but he also designed a considerable number of public buildings both in England and the Dominions.

The most outstanding British

ecclesiastical work of the twentieth century is perhaps Liverpool Cathedral, designed by Sir Giles Gilbert Scott. This imposing building, begun in 1903 and conceived in a modern adaptation of the Gothic style, is one of the few English cathedrals designed specifically for the Anglican Church. When completed it will be the largest ecclesiastical building in England.

A Roman Catholic cathedral is under construction in the same city, to the design of Sir Edwin Lutyens. It will undoubtedly be a most interesting adaptation of the Byzantine style of architecture.

Modern Artists

Among sculptors of the twentieth century we find again a variety of styles and ideas, which reflect the war-scarred and restless spirit of the times. The most outstanding sculptor in Britain is probably Epstein, whose "Rima" panel in the Hyde Park Memorial to W. H. Hudson attracted an immense amount of notice and controversy. His interest here was in design and pattern, rather than subject matter or any attempt at realistic representation. Many other outstanding works by the same artist reflect a strength and angular vitality which is more an analysis of his subject than a representation.

This same quality of analysis has in this century led art into all sorts of forms which cannot be easily understood or appreciated. The age-old method of direct appeal by representation of the external world has been thrust aside frequently in favour of the artist's theoretical tendency and his personal psychological approach to the subject. Thus, abstract art split up natural appearance into geometrical shapes. Surrealism has been an attempt to pictorialize random thoughts, dreams and the world of the subconscious. Incidentally, the word surrealism was coined to express a process of thought that was super-realism.

Such forms of art, which are essentially experiments of the artists, are possibly gratifying to the actual experimentalist, but there are naturally very few people who are in a position to appreciate the process of thought which is a personal quality of the artist concerned. Of such, Picasso and Matisse are probably the outstanding examples of the new freedom of expression, although it has had international influence.

An exhibition of the works of these two artists which was held in London in 1946 aroused fierce, and frequently bitter, controversy, revealing extreme divergencies of opinion on the merits of this form of expression.

Some of the most stirring drawings of the 1940s were executed during the Second World War by the Polish artist Topolski, whose skill and swift handling of pen and brush have supplied an intimate vision of the crowded hours of war-time life. Topolski recorded on paper the violence and discord of his time in the same vivid manner that Goya did over a century earlier (see Fig. 13).

Art in Industry

Art as applied to industry has succeeded, in the last twenty years, in overcoming the more obvious drawbacks with which it was originally faced. Textiles, designs for wallpapers, carpets, glass, pottery, furniture, struggled at the beginning of the century through a

formless phase, in an attempt to produce something new and unusual. A vast number of shapeless "novelties" were produced and found their way into many homes. The idea of employing artists to assist in the design and manufacture of machine-made goods had hardly been born in the first quarter of this century. Gradually, however, this new field of exploration has been widening, and in 1934 the Royal Academy sponsored the movement by holding an exhibition of industrial art, which included a variety of the minor arts and crafts as applied to industry.

These forms of art bring the modern artist into contact with everyday life.

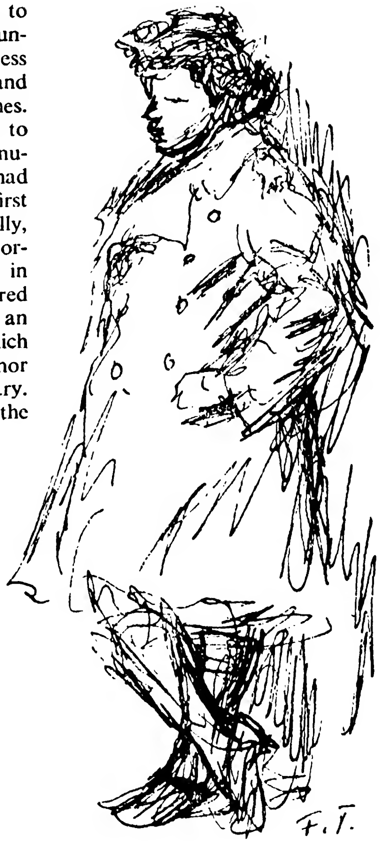


Fig. 13. "*A.T.S. Girl*": *a war-time sketch by the Polish artist Feliks Topolski, showing a member of the British Women's Auxiliary Territorial Service.*

Stage Design

Another sphere of decorative art has, during this century, been greatly developed. This is stage design and more particularly design for the ballet. Apart from the easel picture this is the sphere of modern art where the artist has most scope to express his personal gift of colour and rhythm. Bakst, Benois and, in Britain, Oliver Messel, Rex Whistler, and many other artists have given untold pleasure to thousands with their gay and witty sets and dazzling combinations of colour.

Russian designers gave the ballet its first scintillating brilliance, and the Russian stage has remained a noteworthy product of the age of experiment in design.

The Chinese Tradition

No survey of art, however condensed, would be complete without some reference to the Far East and the ancient traditions and practices that have influenced the art of China, Japan and India.

It is probable that Chinese civilization was flourishing when Egypt and Chaldea were at the height of their artistic prowess. The disciplined skill of the Chinese

artist is visible in all his work that has survived. This is easily understood when we realize that Chinese conceptions of religion are founded essentially on ancestor-worship. The Chinese have, as far as is possible in an ever changing world, remained true to the standards of a former age, each generation devoting itself to the production of exquisite works of art which carried on the tradition. This quality is combined with a technique and sureness of hand and eye which has a perfection all its own.

The wealth of China, with her ivory and jade, gold and silver and other precious stones and metals, furnished a lavish source of material for the artistic skill of her inhabitants. In the present state of our knowledge the history of Chinese art begins to take shape several centuries before the birth of Christ. The practice of the art of painting in this epoch is suggested by literary references.

China's Golden Age

It was during the T'ang dynasty, A.D. 618-907, when the Western peoples were still groping in the Dark Ages, that China reached her Golden Age in all the arts. Buddhism had been introduced from India and took a firm hold on the Chinese people. It incited the Chinese artists to great efforts. Magnificent temples and frescoes, images of Buddha and scenes from his life, made their appearance—but still conceived according to the age-old Chinese standards of beauty.

Towards the end of the tenth century, a revolution took place which brought the T'ang dynasty to a sudden end. This revolution was caused by the swing back towards Confucianism, and it most unfortunately led to the destruction of those things that had gone to the glorification of Buddha. Temples, paintings, metalwork, and sculpture alike were destroyed in the religious frenzy of the Confucianists, in much the same way as the Puritans destroyed some of the best works of the Gothic artists in their enthusiasm for unadorned worship. Owing to this a great part of T'ang art was irretrievably lost.

From the tenth to the fourteenth century, the period including the Sung dynasty (960-1280), Buddhism and art once again flourished hand in hand, and the high standard of cultural perfection thus attained produced masterpieces of Chinese painting on both silk and rice-paper. The Mongol dynasty (1280-1368) returned to earlier styles. The Ming dynasty (1368-1644) once again imitated the T'ang. Technically incomparable artists produced superb porcelain and beautiful paintings. The subjects of the latter were landscapes, flowers, animals and birds. The artists never falter in their delicate and precise line and free brush work. The suggestion of solid form, distance and atmosphere was achieved with a minimum of surely placed strokes of the brush used in the same way as in writing the Chinese characters (see Plate XVA).

Chinese Decline

After the close of the seventeenth century the work of the Chinese artist and craftsman ceased to display the same magnificent qualities. European influence and a popular market in the West for everything that could be produced, both good and bad, have been adverse to the Chinese tradition.

Architecturally, China has clung

to a single model throughout every epoch of her history. This consists of a massive roof with recurved edges resting on short columns—the buildings always face south, and to give added grandeur the roof is doubled or trebled, or even given a dozen such roofs, which turn it into the pagoda shape with which we are all familiar.

Japanese Adaptability

Japan, geographically China's neighbour, has derived much of her artistic ideals and technique from China, but there are nevertheless, many characteristics peculiar to the Japanese artist. Perhaps the most obvious Japanese quality is adaptability. Where the Chinese temperament is accustomed to a long tradition of conformity to established rules, the Japanese is by nature susceptible to change. The Chinese canons laid emphasis on movement in painting. Movement is even more characteristic of the Japanese artist's work, and even in the swirl of a gown or the crest of a wave, there is that air of restless energy which is not discernible in the paintings, however magnificent, of the Chinese (see Plate XVB).

Japan was influenced in much the same manner as China by the Buddhist religion, which came to her by way of Korea in the sixth century A.D., and her paintings and sculpture took the forms already familiar to the Chinese, but adapted to her own particular use and interpretation. The eighth-century frescoes depicting the scenes from the life of Buddha in the Hōryūgi Temple at Nara are wholly Japanese in their vivid linear movement and the intricate patterning of costume, although modelled on Chinese wall painting of the T'ang period.

The lacquered boxes and furniture which we now associate with Japan were originated by Chinese example, but her magnificent bronzes and bronze ornaments are peculiar to Japan. The Japanese were always a warlike nation, and their skill in metalwork goes back to legendary times when the most important metalworkers were the armourers. The craft was inherited, and handed down through succeeding generations. The craftsmanship of Japan shows itself in many ways, uniquely perhaps in the art and craft of the colour print, which was practised by such great artists as Hiroshige and Hokusai, in the eighteenth and nineteenth centuries.

India's Religious Artists

Other countries of the Far East whose artists were vastly affected by the Buddhist religion include Burma, Java and, to a certain extent, India and Ceylon. Fundamentally, however, Indian art is more Hindu than Buddhist, and the strange forms of many-handed and headed figures that represent the gods of India give one a bewildering impression of endless curves and rounded forms, all woven together with intricate pattern and design.

The Indian craftsman from time immemorial was required to be a pious man, his whole life had to be regulated by his adherence to Hindu law and his knowledge of the Vedas or Hindu scriptures. Through this means he could suitably create works to meet the artistic requirements of his priests and patrons. Convention is as much a natural attribute of Indian culture as it is of the Chinese.

Plate XIV. *Edgar Degas was an enthusiastic upholder of the French realistic movement. Just as the French Impressionists of his time studied transient effects of landscape, so he studied transient effects of human movement. Particularly fascinated by the life and lighting of ballets and opera, Degas found endless subjects for his brush and pastels as he sat behind the scenes and sketched the various stages of toilet and rehearsal necessary to the ultimate production of a ballet. This particular picture of "Two Ballet Dancers" shows clearly his technical interest in movement, and he also made a number of pictures of horses racing. His "L'Absinthe" is a fine picture of artist and model at a café table.*

Plate XV. *The examples above show the aspects of (left) Chinese and (right) Japanese art. The Chinese developed a magnificent technique of painting in Chinese ink on silk and rice-paper. A fine free brush-work that never falters in its lovely rhythm is combined with soft, clean colours applied with decision and not retouched. Japanese art is derived from China, although it is less reposeful and requires its own distinct convention. The same careful arrangement of space and pattern, shapes and colour-values is apparent in both China and Japan.*

CHAPTER 12

LITERATURE OF THE WORLD

Definition of literature. Chinese and Indian literature. Religious contributions to world literature. The heritage from Greece and Rome. Medieval romances. Italian contribution. Literature of the French and Spanish Renaissance. Early English contribution. Elizabethan, Puritan and Reformation literature. Seventeenth- and eighteenth-century French and British literature. Romantic revival. British and French literature in the nineteenth and twentieth centuries. Literature of Germany, Russia and Scandinavia. The American contribution to modern literature.

THE term literature is often carelessly applied to anything written or printed. Thus, a parliamentary candidate will speak about distributing his party's literature to the electorate. In the present chapter, however, the word is used to signify writing of outstanding quality—the expression of human thought and feeling in language which is memorable. And, since there is so much good writing in the world it is only possible to deal with the masterpieces of literature.

Great literature generally has a strong emotional content, so much so that to a person who is sensitive to its appeal it is almost impossible to read aloud. There is magic in words: they have the power to weave a spell, to stir the heart, to awaken echoes from the past.

We are apt to regard masterpieces of literature as the unaided work of individual geniuses. Tolstoy alone wrote *War and Peace*; Cervantes wrote *Don Quixote*; Milton wrote *Lycidas*. But it should be realized that a work of literary art does not spring from the writer's mind as Pallas Athene sprang from the head of Zeus; whether he knows it or not, every original writer owes much to others who have preceded him. It would be well to think of a masterpiece as a river to which many streams have each added something of value.

On the other hand, a great drama, a great poem, a great novel might be likened to a giant tree which sends branches in many directions and scatters seeds which eventually become new forests. The Greek poet Homer, for example, wrote the *Odyssey*, describing the wanderings of Ulysses, including his journey into the underworld where he talked to the souls of the departed. Centuries later the Roman poet Virgil wrote a similar story about the adventures of Æneas, who also took a journey into the world of shades. Centuries later still, the Italian poet, Dante, wrote his most famous poem, the *Divine Comedy*, in which he narrates how he, accompanied by the ghost of Virgil, went on a strange and terrifying journey through Inferno. The influence of Dante spread to other countries, and one cannot help comparing his *Comedy* with Milton's *Paradise Lost*.

The most discussed novel of

recent years—the most highly praised and the most vehemently denounced—is based upon the general plan of Homer's *Odyssey*. From the first story about Ulysses to James Joyce's novel, *Ulysses*, through an interval of twenty-eight centuries, the influence of one of the world's supreme masterpieces has never waned.

When one remembers the chief handicap of literature—the language barrier between nations—it is surprising to learn how its ramifications extend from country to country, from age to age. Greece inspires Rome; Rome inspires Italy; the Italian stories of Boccaccio are borrowed by Chaucer; the stories of Plutarch are adopted by Shakespeare; the plays of the Norwegian dramatist Ibsen react upon Pinero and Bernard Shaw. Through translation, the great literature of the world becomes international.

What has been said seems to suggest that literature began in Greece, and certainly the world owes an incalculable debt to the great Greek writers of the past. We think of her dramatists, her epic poets, her philosophers. Indeed, a modern critic has said that there was more genius in Athens at one time than in the whole of Great Britain and America today. But Greece owed something to Egypt, and, further back still, to the philosophers of India.

Chinese Writings

Perhaps the best place to begin is in the Far East—in China, which reached a high standard of culture and civilization when Europe was still barbarian.

It must be confessed at the outset that most Europeans are profoundly ignorant about Chinese history. For one thing the country was for many centuries so inaccessible that it might have seemed to be in another planet; for another the inhabitants closed their doors to "foreign devils" whom they regarded as an inferior race; and the language difficulty appeared an almost insuperable barrier.

China had a great civilization before the Christian era began. We can appreciate her architecture, her painting, her sculpture, her pottery and other works of art because we can see their merit; but we can appreciate her literature only in translation. Chinese songs and ballads date from the ninth century B.C. Her poets wrote odes about war, feasting, drinking, dancing, and love; but they wrote about the friendship between men rather than about the love of man and woman—the constant theme of European poetry. The most glorious period for Chinese poetry was in the T'ang dynasty (round about A.D. 700), when two of her finest lyric poets were Li Po and Tu Fu. They were romantic figures who lived gay, care-free lives of wandering. Later periods, like the Sung dynasty and the Manchu, were more seriously inclined. The chief moods of China's poetry were excited by a deep delight in natural beauty, and a warm sympathy for suffering humanity. Many of the best Chinese poems have been translated by Arthur Waley, to whom we owe much for his efforts to make the East intelligible to the West.

The earliest literature of any country is generally religious. Five or six centuries before the Christian era, two great leaders of religious thought appeared in China, and

their influence is still dominant to this day. The elder was Lao Tzu, the founder of Taoism, about whom many strange stories have been told. Thus he was born an old man, and according to his disciples he went to heaven on the back of a black buffalo about the year 523 B.C. He was a fierce ascetic, had a great contempt for social position and wealth, regarded ignorance as a blessing and labour as a curse. His *Book of Reason and Virtue* is his chief contribution to the religious literature of the East.

His rival, Confucius, was probably a private person who taught the sons of gentlemen the virtues proper to the ruling classes. He may have been an agnostic—he taught no theology as we understand it—but concentrated upon the importance of good character. But as time passed the stories about Confucius accumulated and grew more strange. He became credited with omniscience and infallibility (though he made no such claim), and eventually was known as the Divine Sage. His followers today number hundreds of millions.

Analects of Confucius

The chief sayings of Confucius have been preserved in the *Analects of Confucius*—one of the world's great books, and included in the list of the Hundred Best Books prepared by Lord Avebury. The book can be had in translation and can be enjoyed very much as one enjoys the sayings of Dr. Johnson.

When one of his disciples boasted that he always thought three times before taking action, Confucius replied: "Twice would do"; and to another who wanted to be educated into a worthy citizen the Master dismissed the idea with the curt decision. "Rotten wood cannot be carved."

The *Analects of Confucius* may be mentioned as the typical contribution of China to the world's literature. There are many other contributions, undoubtedly, but they have made little impression outside the Flowery Land.

This is like dismissing astronomy with the description of one star. The subject, however, is so vast that it would require whole volumes to do it justice.

There is Japanese literature, too. Its philosophical thought owes much to China, and can be dismissed with a passing word, but there were original writers of lyric poetry twelve centuries ago.

India's Contribution

India has given the world great works of philosophy and religion, and her Sacred Books have influenced the lives of millions. She has great epic stories, too, notably *Mahābhārata* and *Rāmāyana*, but they are little appreciated outside the country itself. Still, the Indian contribution to philosophy is being studied more seriously in the West than it has ever been before, and the full impact upon our habits of thought will be more fully realized in years to come. Among India's poets mention must be made of Rabindranath Tagore, winner of the Nobel prize in 1913, and famous for his *Gitanjali* (Song Offerings) and *One Hundred Poems of Kabir* (see Fig. 1).

The Bible

In thinking of great religious literature it is natural for western peoples to put the Bible in the supreme place. The Bible, however,

is not so much a book as a library of sacred writ. The Old Testament, which Christians venerate with the Jews, has thirty-nine books (excluding the Apocrypha) and was written in Hebrew. It has been translated into hundreds of languages. To people in Great Britain today the most familiar version is the Authorized, made by a committee during the reign of James I. The Revised Version may be more accurate but it seems to lack something of the majesty of its predecessor It has also been translated into the twentieth-century idiom, but most people prefer either the Authorized Version or the *Literary Man's Bible* edited by Ernest Sutherland Bates.

With the theological ideas of the Old Testament and its rules for good behaviour we are not concerned here. We are thinking only of its merit as literature. Even the man who will have none of its teaching will not deny the magnificence of its language. Admittedly some parts are more impressive than others. But for sheer beauty of language there are passages which are incomparable, for example, certain of the Psalms (19, 23, 37, 91, 100, 121, 137, and 139), the 39th chapter of the Book of Job, the 35th, 40th, 53rd, and 55th chapters of Isaiah, the Book of Ruth (which Dr. Johnson read aloud until his hearers wept), the Song of Songs—an exquisite love story—and the pessimism of Ecclesiastes.

The stories of Abraham, of Joseph, of David, of Solomon, are perfectly told and they are full of dramatic interest.

The New Testament has twenty-seven books and was written in Greek; to Christians it represents the fulfilment of the Old. It has passages of the greatest beauty like I Corinthians 13 and 15, Hebrews 11, and Philippians 4, as well as the great Sermon on the Mount (St. Matthew, 5 to 7). The Jews, who do not accept the New Testament, have a much longer book in their Talmud.

Other examples of great religious literature include such books as the *Confessions of St. Augustine*, Thomas à Kempis's *The Imitation of Christ*, Jeremy Taylor's *Holy Living* and *Holy Dying*, Richard Baxter's *The Saints' Everlasting Rest*, and Bunyan's *The Pilgrim's Progress*. These are all Christian contributions to world literature.

The Koran

One other great book of enormous importance to millions of people is the Koran, written (or dictated) by Mohammed. To the world of Islam the Koran is the book of books. It not only explains the philosophy of life and death but gives minute instructions about human conduct. To the man who is not a worshipper of Allah it is heavy reading. Carlyle, who regarded Mohammed as one of his "heroes," tried hard to struggle through the whole of the Koran but gave in.

The Koran was written during a period of years, in intervals of fighting, and the scattered passages were written on "palm leaves, skins, blade bones, and the hearts of men." At first it was memorized by faithful Moslems, but later on the Prophet's secretary collected the texts in book form, arranging the texts in order of length—the later messages coming first, the earlier ones at the end. To quote from C. E. Storrs's *Many Creeds*—

One Cross, "the Koran is reverenced by Moslems as the infallible word of God, delivered to the Prophet through the angel Gabriel. Mohammed indeed confessed to being a human prophet, sinful, and on one occasion fallible; but his revelations were infallible."

But similar claims are made about the sacred books of all the great religions. It is difficult for anyone who is ignorant of Arabic to feel the dignity of the rhymed prose in which Mohammed spoke.

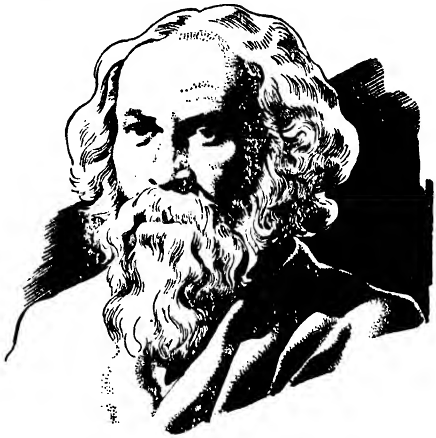


Fig. 1. *Sir Rabindranath Tagore, winner of the Nobel prize for literature in 1913, was one of India's greatest authors and poets.*

The Mohammedan religion is later than Christianity. The Prophet lived at the end of the sixth and the beginning of the seventh centuries. His followers today are said to number over two hundred million.

These, then, are the fundamental religious books of the world: the Old Testament, the New Testament, the Talmud, the Koran, the Analects of Confucius, the Sacred Books of India. If we have said nothing about the religious books of Greece and Rome it is because their influence has completely disappeared. The mythology of the classics, with its everlasting intrigues between gods and goddesses, and between gods and mortals, is nowadays a subject only for mirth.

The Greek Heritage

Greek literature begins with Homer, who lived somewhere in the eighth or ninth century before the Christian era. He is a mysterious and mystifying person. Some authorities have doubted his very existence. No fewer than seven places claim the honour of being his birthplace. There are some people who believe that in later life he was blind.

But someone must have created the *Iliad* and the *Odyssey*, though here again there is trouble, for some critics think they were written by different people. Samuel Butler, author of *Erewhon*, tried to prove that the *Odyssey* was the work of a woman! Goethe, Schiller, Matthew Arnold, and Gladstone believed in one Homer who composed both works, which were memorized and handed down from generation to generation before they were put to paper. According to the *Oxford Companion to Classical Literature*, "many authorities have questioned Homer's very existence as an individual poet. . . . But recent scholarship tends to recur to the view 'one Homer' who perhaps worked on pre-existing materials

and remodelled them into complete poems, each possessing unity and each inspired by an artistic purpose." This can be accepted as the most up-to-date, balanced estimate on the whole problem.

The Iliad

The *Iliad* is the story of the siege of Troy by the Greeks. The notorious Helen of Troy was the beautiful wife of Menelaus, and was stolen by Paris while her husband was away at the wars. The chief character is Achilles who sulked in his tent for years before he joined in the fight. His temper was caused by a quarrel with the Greek king, Agamemnon, who had seized Chryseis, daughter of the priest of Apollo, as one of the spoils of war while Achilles had taken Briseis. Owing to the anger of Apollo against Agamemnon, the king was compelled to restore Chryseis to her father; but he took Briseis by way of compensation. Hence the ill-temper of Achilles.

It is a complicated story in which gods and goddesses took sides for and against the various leaders in the war. Achilles was in the act of drawing his sword to attack Agamemnon, for example, when Athena came down from heaven and held him back by his long red hair! No other man saw the goddess. When Achilles expostulated with her for holding him back she promised that she would give him a splendid opportunity for revenge later on.

The *Iliad* describes the war in great detail. The great hero on the Trojan side was Hector, and there is a marvellous and moving account of his farewell to his wife, Andromache, and his little son before he went out to fight. He had a great duel with Ajax and slew him. But the climax of the whole story is the description of the fight between Achilles and Hector, in which the latter was slain. Achilles tied his vanquished enemy to the back of his chariot and dragged him three times round the walls of Troy. The funeral of Hector is the concluding episode in the poem. The well-known story of the wooden horse of Troy is not mentioned.

The Odyssey

The all-important character in the *Odyssey* was Ulysses (or Odysseus), who combined great courage as a warrior with a large admixture of cunning. He was in the war with Troy, having left his wife Penelope safe at home in Ithaca. When the battle was over, Ulysses went on a roundabout voyage home, and the poem relates his innumerable adventures on the way. Many of these adventures are well known—the fight with the one-eyed giant, Polyphemus, whom he blinded in his cave; the journey to the underworld; the encounter with Scylla and Charybdis, the temptation of the Sirens who lured sailors to destruction, the affair with Circe who transformed men into swine, and the years he spent in the island of Calypso who bore him several sons.

Penelope, however, remained faithful to Ulysses, although the home was haunted by suitors who tried to persuade her that her husband was lost. She resisted for years. In the end she promised to choose a new husband when she had finished her famous weaving. To postpone the time of decision she worked at her weaving during the day and undid it during the night. Before the fateful decision

could be made, Ulysses reappeared in the disguise of a beggar, watched the behaviour of the suitors until his patience was exhausted, and then attacked. With the help of his son, Telemachus, now grown up to young manhood, Ulysses slew the suitors, and the poem ends "happily ever after."

The *Iliad* and the *Odyssey* are two of the earliest epic poems in the world and their appeal never weakens with the passing of the years. The *Iliad* interests us because life is a battle; the *Odyssey* because life is a journey. It is true that Troy was only a small town and the numbers engaged were but a handful in comparison with the vast armies employed in a modern war. But the value of creative work does not depend upon its magnitude but upon quality. A straw-thatched cottage may be worth only a couple of hundred pounds when regarded as property, but the painting of that cottage by a great artist may be priceless. Something of the kind may be said about the importance of the Homeric story of Troy. Helen was a lovely woman, no doubt, and there are thousands of lovely women—in Hollywood, for example—but Helen is immortal.

Translations of Homer in verse have been made by Chapman and by Pope. Keats has recorded the thrill which he experienced when he first read the Chapman version. The stories have been retold in prose many times.

Greek Drama

Ancient Greece was the first European country to give the world great drama. It was performed in the open air in vast amphitheatres where the actors appeared very small but they padded themselves to add to their size and they spoke their lines through speaking trumpets.

Tragedy reached greater heights than comedy. Æschylus, who lived about 500 B.C., wrote seventy plays, seven of which still survive. Sophocles wrote over one hundred, but of these also only seven survive. He won the first prize for drama at least twenty times but he never won a second or a third.

Euripides was perhaps the greatest of the tragic dramatists. About seventeen of his plays have been preserved, including *Medea*, *Electra*, *Andromache*, and *The Trojan Women*. He died in 406 B.C.

Greek comedy is best represented by Aristophanes who lived 448 to 380 B.C., as nearly as we can tell. His plays may strike us as vulgar, occasionally improper, but it is surprising to notice how many of his jokes are essentially the same as those still being used by comedians in the modern music hall. He frequently poked ridicule at the celebrities of his day; thus he made fun of Socrates in *The Clouds* and Euripides in *The Frogs*. His farcical *Lysistrata* shows how the wives of Greek warriors brought war to a swift end by denying the men conjugal rights when on leave!

Greek Philosophy

Ancient Greece excelled in philosophers, the outstanding names being those of Plato and Aristotle. They thought deeply about many of the problems with which we are still struggling today: problems of government, autocracy *versus* democracy, right and wrong conduct, the duties and responsibilities of citizenship, the best kind of education.

Plato's *Republic* is one of the

world's masterpieces. It deals with the teachings of Socrates, an ugly, snub-nosed little man who was born about 470 B.C. In his early days he was a soldier and won distinction for his acts of bravery. Later in life he was excited by the lectures of the Sophists who might be compared to the rationalists of modern times. They ridiculed the popular superstitions about the gods; they upset traditional ideas; they had modern theories about astronomy, science, politics. For a while they were the rage of Athens. The young people were enthusiastic about them.

Socrates himself was not only interested but was intensely excited by this new teaching and he had an embarrassing trick of asking the Sophists exactly what they meant by the terms they used so glibly. What does one mean by justice? Why is a thing considered beautiful? Why is this action right and that wrong? Living in an atmosphere of perpetual discussion, and moving about challenging speakers to explain what they meant, Socrates gained a great reputation and a large following. The famous oracle pronounced him the wisest man alive.

Socrates was glad to see the old superstitious nonsense destroyed, for he valued exact knowledge over everything else in the world. Incidentally his religion (which he did not get from the Sophists), often anticipated Christian teaching: he was probably the first European to believe in immortality. Finally he came into direct conflict with the authorities who charged him with preaching heresy and corrupting the youth of his time. He was condemned to die by drinking hemlock. The story of his death is well known : it has been broadcast a number of times.

Aristotle's Ethics

Aristotle was also a great teacher and thinker, and the notes of his lectures have been preserved by his followers. He and Plato differed on certain subjects. The student who wants to get a fair idea of the whole range of his thought should read Aristotle's *Ethics*. It deals with such subjects as happiness,

Fig. 2. *A bust of Herodotus, who was commonly known as The Father of History. He was born at Halicarnassus, a Greek colony in Asia Minor, and died in 425 B.C., aged about sixty.*

moral goodness, justice, virtues of the intellect, pleasure, wisdom, friendship, and so on. He was a scientist, a psychologist, a metaphysician, a logician, a teacher of ethics, most of whose work is pertinent in the twentieth century.

The Greek Cavalcade

Greece also produced lyric poets like Anacreon, scientists like Pythagoras, orators like Demosthenes, historians like Herodotus ("the Father of History," see Fig. 2), and Plutarch (from whom Shakespeare borrowed for his plays like *Coriolanus* and *Julius Cæsar*).

Before leaving the subject of the Greek contribution to literature, perhaps one other name should be added—that of the first woman to achieve distinction in literature. Sappho was born in Lesbos about 600 B.C., and she wrote a great number of passionate lyric poems. Only two complete poems have survived, although there are fragments of many more. There are many legends about her, which do not enhance her reputation for virtue, and there is a doubtful story that she committed suicide.

Ancient Rome

After " the glory that was Greece," came " the grandeur that was Rome "; for Rome became the centre of civilization. She owed a great debt to Greece; her poets were inspired by Greek poetry of earlier centuries but Latin literature cannot be dismissed as merely imitative.

The young boy who is sent to an English public school is set to work construing his *Julius Cæsar* from which he learns not only the language but a good deal of Roman history. When he has mastered that sufficiently he is likely to study the epic poetry of Virgil or the odes and satires of Horace. Later still, perhaps, he studies the prose of Cicero, Sallust, Tacitus or the drama of Plautus. This type of education is often criticized. Why, it is asked, should these boys waste time on the dead languages of Greece and Rome instead of giving more time to English literature? What is the use of it? Why not scrap the classics and devote the time to science, geography, modern history?

The answer is that at no time in the world's history did human thought reach greater heights or depths. The statesman who knows his Greek philosophers is mentally equipped for any modern problem which may confront him. It gives him a background, eternal standards, and an attitude to life in general which can only be described as that of a man of culture.

The Classical Tradition

Greece and Rome were enlightened when the rest of Europe was sunk in barbarism. For centuries their literature and art were forgotten. But they were re-discovered at the end of the Middle Ages—a period known as the Renaissance—when there occurred a great intellectual awakening throughout Europe. Italy, Spain, Holland, Germany, and England all caught the enthusiasm for learning. Universities were founded; the first schools were established, and the study of the classics was regarded as the be-all and end-all of education. The tradition has lasted to the present day.

Scientific works were written in Latin—Newton's *Principia* for

example—and in the churches the prayers were said in Latin. Without a knowledge of Latin and Greek a man did not consider himself educated at all. He learnt his philosophy from Plato and Horace; he quoted Homer and Virgil in his speeches in Parliament; and even the English essayists interlarded their writings with tags of Latin and Greek to give them the true flavour of cultured thought.

We can read the classics in translation, of course, but it must be confessed that even in the best of translations something of vital importance is completely lost.

The Medieval Romances

Rome was at the heyday of her literary creativeness shortly before the birth of Christ (Virgil was born in 70 B.C., Horace in 65 B.C.). But after the fall of Rome there seemed to be long centuries which produced no work of importance. Indeed some critics appear to take a flying leap from then to the beginning of the Renaissance in the fourteenth century.

Still, the period was not so barren as one may think from a cursory glance. During the Middle Ages there were created many legends about the great warriors and their ladies. It was the epoch of the knight errant, with its high ethical code of chivalry and its deeds of derring-do.

There were stories of Alexander, of Charlemagne, of Tristan and Iseult, of Roland and Oliver, and delightful stories like the twelfth-century French *Aucassin and Nicolette*. The innumerable stories of King Arthur and his gallant knights belong to this period, though it is difficult to decide just where they originated. Some of them are unmistakably Celtic and belong to Wales; others are claimed for the Celts in Brittany, for the legends are known on both sides of the Channel.

In France these heroic stories were told or sung by wandering troubadours and *jongleurs*; in Germany by the *minnesingers;* in Britain by strolling harpers like the one described by Scott in *The Lay of the Last Minstrel.* The stories passed from country to country and may have been known for many years before anyone tried to record them in black and white.

The stories upon which Wagner based his cycle of operas—the *Nibelungen*—belonged to this period of medieval romance, so that today most people are as familiar with Siegfried and Brunhild as with the Arthurian stories. Geoffrey of Monmouth told the Arthur stories soon after the Norman Conquest of Britain; they were retold with great literary skill and power by Malory later on; but to the Victorians the stories were best known through Tennyson's *Idylls of the King*—The Coming of Arthur, Gareth and Lynette, Geraint and Enid, Merlin and Vivien, Lancelot and Elaine, The Holy Grail, The Last Tournament, Guinevere, and The Passing of Arthur.

There is hardly a schoolboy in Great Britain who has not heard of the magic sword Excalibur, and the way in which Sir Bedivere carried the dying king on his shoulders till he was put on board the funereal barge and lamented by the "three queens with crowns of gold."

When the story of King Arthur was new he was a valiant warrior who fought gallantly against the invaders of his native land; in process of time he became an

immortal who was destined to return and save Wales once again.

One of the finest of the stories of knightly courage was the extraordinary legend of Sir Gawain and the Green Knight—said to be one of the jewels of the Age of Chivalry—which has lately been retold in modern English by M. R. Ridley. It was written before the year 1400 and happened in the days of King Arthur, although the story starts with a mention of the fall of Troy.

Many of the foreign stories of knightly chivalry like *Orlando Furioso* and *Amadis of Gaul* inspired the courage of Don Quixote whose deeds were laughed away by the Spanish writer Cervantes, who died in 1616. The stories which found the greatest currency in Wales have been collected into the famous *Mabinogion*. In France, Froissart's *Chronicles* gave the history of England, Scotland, France and Spain.

Dante's "Divine Comedy"

Although the Italian language is derived from the Latin of earlier centuries, there was no Italian literature worthy of the name until the Middle Ages. All the poetry before Dante dealt with human love but none of these lyrics call for special notice.

Dante Alighieri (to give him his full name) was born in 1265. He was a man of action as well as a poet. He had dreams of a perfect city-State which he strove to create by political power until he went into exile under sentence of death.

His supreme masterpiece, the *Divine Comedy*, was essentially religious in theme. It sprang from burning faith, fanned into flame by intensity of imagination.

It begins by telling how Dante, wandering in a dark, forbidding wood, encountered the ghost of Virgil who accompanied him on a pilgrimage through hell. Inferno is described as a series of nine terraces, going deeper and deeper into the earth. Each stage is pictured with minute and terrifying detail.

Milton's idea of hell, set forth in *Paradise Lost*, was vague and chaotic; Dante's was precise and definite. Some of the hells were fierily hot, where flakes of fierce flame fell on the naked bodies of sinners; others were icy cold, with everlasting snow and sleet. In one hell the souls of the unbaptized were perpetually hurled by violent gales against sharp rocks; in another there were rivers of boiling blood, the odour of which was sickening; in a third there were serpents which flung themselves on the souls in torment, causing them to burst into flame. Each type of human sin had its own particular form of torment. Those who had tried to foresee the future were punished by having their heads turned to the back so that they could not see what lay before them.

One haunting picture was of a man who carried his head in his hand like a lantern. When he saw Dante, the head addressed him and explained why he had been so condemned. In the lowest hell of all was Satan himself—not a proud, rebellious angel like the Satan of Milton or the Apollyon of Bunyan, but a three-headed monster buried up to the waist in burning red-hot ground. One of the heads was black; another was a jaundiced yellow; the centre one was scarlet. In each of his mouths Satan was chewing a sinner: the scarlet jaws were chewing Judas Iscariot.

It is impossible to tell the whole

story of the *Divine Comedy*. After the nine phases of Inferno there came the nine phases of Purgatory —cut into terraces on the slopes of a mountain—and then came the nine phases of Paradise which carried Dante to distant planets. Each stage was more beautiful than the last, and at the ultimate climax the poet had a vision of Beatrice—symbol of human love lifted to its highest spiritual plane.

When the dark-faced, solemn-looking Dante walked the streets of his native Florence, men glanced at him, whispering " That man has seen hell! " It must be remembered that in the fourteenth and fifteenth centuries hell was a more vivid and terrifying reality than it is in this sceptical twentieth century. The story of Dante's love for Beatrice is one of the classic love stories of the world.

Of course Dante wrote much else of merit besides the *Divine Comedy*, and modern poets like T. S. Eliot constantly quote him with admiration. The present Poet Laureate, John Masefield, included Dante in his list of twelve great books for young people. Many writers have translated Dante into English: Longfellow, for example, turned the *Comedy* into English verse.

The " Decameron " of Boccaccio

Another great Italian in these early centuries was Boccaccio, author of the one hundred short stories collected into a volume known as the *Decameron*. In his early days he moved in an aristocratic society whose members seemed to devote all their days and nights to love-making. The whole atmosphere was full of intrigues, deceptions, affairs; and there was a Court of Love to settle the laws of the game (the characters in the English Restoration plays appear to have been similarly preoccupied).

Boccaccio imagined that a number of people, scared of the plague that ravaged the country in those days, shut themselves up in a secluded country estate and spent their time in the telling of tales. Some of these the author invented, others he borrowed. But the general impression of the whole *Decameron* is of a collection of improper or *risqué* stories which would certainly arouse the wrath and disapprobation of the Church. There is no more complete contrast to the work of Dante.

Machiavelli and Cellini

Other great figures in early Italian literature were the poets Petrarch, Ariosto and Tasso; and the prose writer Machiavelli, whose book *The Prince* is sometimes regarded as an inspiration to cynical politicians, especially those with a tendency towards fascism. Here are one or two stray sentences which are characteristic:

" Princes who have done great things have held good faith of little account, and have known how to circumvent the intellect of men by craft, and in the end have overcome those who have relied upon their word."

" He who has best known how to employ the fox (in human nature) has succeeded best. But it is necessary to know well how to disguise this characteristic, and to be a great pretender. . . . Men are so simple that he who seeks to deceive will always find someone who will allow himself to be deceived."

" It is unnecessary for a prince to

have all the good qualities I have enumerated, but it is very necessary to appear to have them."

"Fortune is a woman, and if you wish to keep her under it is necessary to beat and ill-use her. She allows herself to be mastered by the adventurous rather than by those who go to work more coldly. She is always a lover of young men, because they are less cautious, more violent, and with more audacity to command her."

Perhaps one other Italian writer should be mentioned at this point, although he belongs to the beginning of the sixteenth century—Benvenuto Cellini—whose autobiography is world-famous for its candour and bombast. He can be dismissed as a scamp, but the naive way in which he exults over his achievements reveals him as one of the greatest egotists of all time. However much one may disapprove of him, it is impossible not to laugh with as well as at him.

French Renaissance Writers

The great awakening which followed the Middle Ages in Italy, when poets, painters, and sculptors appeared to be as numerous in Florence as men of genius in early Athens, spread to other countries. The Renaissance was inspiring France before it was felt in England.

There was Montaigne, for example, generally acclaimed as the first essayist—the pioneer of a long line of essayists which goes on to this day. The first Englishman of note to follow in his train was Francis Bacon, whose essays are models of concentrated thought and deft exposition.

There was the great Rabelais, secular priest and physician. In 1531, when he was about thirty-seven years of age, he wrote his first masterpiece based upon a local legend of a giant. It is called *The Great and Inestimable Chronicles of Gargantua*, and a year later appeared its sequel, *The Horrible and Terrible Deeds and Prowesses of the well-renowned Pantagruel, Son of the Great Giant Gargantua.* One cannot read Rabelais' two stories without what has come to be called Rabelaisian laughter. The books undoubtedly owe much to a Latin writer, Lucian, but they are written with a *joie de vivre* and in a spirit of humorous mockery that was characteristic of the times.

Judged by modern standards the tales about Gargantua and Pantagruel are coarse, often improper and even pornographic; but the same charges can be brought with equal force against the literature of the Elizabethan period in English literature. Certain plays of Shakespeare are banned from schools and those that are studied are carefully sub-edited to save the teacher from embarrassment.

Something must also be said about French poetry of which there was a tropical abundance. The most outstanding figure of this era is that of François Villon who was born in 1431. In his early days he killed a priest and fled for his life. He was a notorious burglar and scallywag, but he wrote the most delightful poetry. One of his finest poems was composed on a night when he expected to be hanged the next morning. An extraordinary character! Apart from his numerous ballads he is remembered for *Le Petit Testament*, written at the age of twenty-five, and *Le Grand Testament*, five years later.

Robert Louis Stevenson admired Villon immensely and wrote an

essay about him. He himself always longed for a life of vagabondage and hoped ultimately to be found dead in a ditch. In his short story, *A Lodging for the Night*, he describes one of Villon's adventures. It ends on this note :—

" The old man stretched out his right arm. ' I will tell you what you are,' he said. ' You are a rogue, my man, an impudent and black-hearted rogue and vagabond. I have passed an hour with you. Oh! believe me, I feel myself disgraced! '

" ' Goodbye, papa,' returned Villon, with a yawn. ' Many thanks for the cold mutton.'

" The dawn was breaking over the white roofs. Villon stood and heartily stretched himself in the middle of the road. ' A very dull old gentleman,' he thought. ' I wonder what his goblets may be worth.' "

Many readers who have no acquaintanceship with Villon's poems at least remember his name and his reputation. He was the hero of a successful musical play, *The Vagabond King*.

The Spanish Contribution

The literary revival spread from Italy to France, and thence to Spain and England. The one outstanding name in Spanish literature at this time was that of Cervantes, author of *Don Quixote*. This is the story of a Spanish madman whose head had been turned through reading too many romances of knight-errantry and who fancied himself as another Sir Galahad.

He mistook a windmill for a giant and charged with fury, mounted on his gallant steed Rozinante, but the turning sails sent him sprawling to earth; he attacked a flock of sheep under the delusion that they were demons disguising themselves to escape his vengeance; and he sat before a village tavern all night keeping vigil over the barmaid who (he was convinced) was a princess and who made great sport of the crazy fellow sitting like a statue in the moonlight.

Don Quixote has become an amusing story for children! But anyone who reads the whole work will realize that it is something far greater than a tale about a queer fellow—rather like the White Knight in *Through the Looking-glass*. It is a satire on the ancient order of chivalry and its romantic literature. As Lord Byron said in *Don Juan:*

" Cervantes smiled Spain's chivalry away."

Boccaccio's stories in the *Decameron* were frankly pagan; they might be described as either immoral or non-moral. To its characters life was nothing more than a game of love-making. Cervantes' immortal story goes deeper. To Don Quixote life was a crusade against the evil in the world. The man may have been mentally deluded, for his pate was full of the craziest hallucinations; but he was morally right. No one can deny either his courage or his sincerity. He had the madness of a fanatic.

Like all the stories of the period *Don Quixote* contains much which would be considered bad taste today. There are interludes that are vulgar if not positively indecent. Sancho Panza, the Don's faithful squire, represents the animal in human nature as the knight himself represents the spiritual.

Cervantes died on the same day

as Shakespeare (April 23, 1616), and if one has a liking for fantasy it would be interesting to imagine the meeting of these two tremendous figures in the world hereafter.

There have been other great Spanish writers like Don Calderon (one of whose plays was "borrowed" by Shakespeare in the opening and closing scenes of *The Taming of the Shrew*) and Lope de Vega whose activities alternated between love-making and writing plays. The theatre was his all-consuming passion. In later life he became the idol of the public and the favourite of princes. Nevertheless he was very poor for the greater part of his life. What strikes the modern dramatist as incredible is the report that he composed no fewer than 1,800 comedies in addition to innumerable poems and other forms of literary exercise. Surely the world record for fertility of output!

English Literature Before the Renaissance

Many critics consider that English literature is the richest in the world. The Renaissance, which inspired Italy to painting and poetry, inspired England to literary activity.

There was little literature before the Norman Conquest which is likely to be read today except by students who are obliged to do so. The dragon-slaying epic about Beowulf which was probably known before the fifth century might be mentioned, and of course, there was the *Anglo-Saxon Chronicle* in the time of King Alfred. There were the religious poets, Caedmon and Cynewulf, who lived somewhere about the seventh century. Caedmon is often described as the first English poet. Arthur Compton-Rickett tells this story of him:

"He was a simple, unlettered man, an inmate of St. Hilda's monastery, near Whitby, to whom fell the task of looking after the cattle. Leaving the feast and the singers, because he could not take part, he fell asleep among the cattle. And while he slept he dreamed that one came to him and commanded him to sing. 'Of what am I to sing?' said Caedmon. 'About the beginning of created things.' He then fashioned a song about the Creation and awakened from his dream. The song he remembered, and many more like it. And after this he became a monk. The Bible was read to him because he could not read, and he would turn those passages into verse."

Hence, Caedmon's *Paraphrase* which served as a model for other poets, Cynewulf among them.

The first big name after the Norman Conquest is that of William Langland, author of *Piers the Plowman*, who was born in 1332, a few years before the great Dan Chaucer. He was tall and lank, proud and moody, and had none of the social graces. His poem was a picture of the life and manners of his time, a violent attack on the follies and abuses of the age, and an allegory of human life. He bitterly reproaches those who shirk honest work for a living, denounces the drunkard and the oppressor of the poor, the tradesman who cheats, and the preacher who does not live up to his creed.

Chaucer's "Canterbury Tales"

Perhaps the first literary masterpiece of England which is still read with pleasure is *The Canterbury Tales* of Chaucer (see Fig. 3). It

Fig. 3. *Geoffrey Chaucer (1340-1400), the son of a London wine merchant, is known to this day as The Father of English Poetry. His "Canterbury Tales" have recently (1946) been translated into Russian for the first time. The drawing above is based on one in a manuscript copy of "The Canterbury Tales," which is beautifully adorned with marginal paintings.*

is a monumental work. The poet describes a company of pilgrims on their way to the Holy Shrine at Canterbury, and to beguile the time they tell stories of many kinds. Many of these stories were borrowed from other lands, but the Prologue which gives pen portraits of the members of the party is pure Chaucer and is probably the best part of the book.

Two of the stories are in prose;

the rest (some seventeen thousand lines) are in verse made of rhymed couplets. To our twentieth-century eyes Chaucer's poetry appears queer and his spelling odd; in fact, some portions are almost unreadable unless one has made a study of Old English. About three hundred years later, the poet Dryden re-wrote Chaucer in a style that anyone can understand and enjoy. He was severely criticized for doing this, but he defended himself valiantly :—

" I grant that something must be lost in all translations; but the sense will remain, which would otherwise be lost, or at least be maimed, when it is scarce intelligible. I think I have just occasion to complain of them, who, because they understand Chaucer, would deprive others of the same advantage, and hoard him up, as misers do their gold, only to look on it themselves."

The main characters in *The Canterbury Tales* are the knight, the squire, the yeoman, the prioress, the monk, the friar, the clerk, the man of law, the franklin, the wife of Bath, the parson, the miller, the reeve, the summoner, the pardoner, and the poet himself. They assembled at the Tabard Inn. The story-tellers were chosen by drawing lots. The first story was told by the knight—the story of Palamon and Arcyte who fell in love with the beautiful Emilia whom they saw walking in her garden on a May morning. A romantic story, sad in parts, but ending with the marriage of Palamon and Emilia.

The priest told an ancient fable about a cock which outwitted the fox who had captured him; the pardoner told a Flemish story about three rioters who went to destroy death and were themselves destroyed; the wife of Bath told the story of the knight who was sent on a quest to discover what women like best in the world.

But one of the best known of these *Canterbury Tales* was the one told by the clerk of Oxenford—the story of Patient Griselda. It is impossible, however, to gain an idea of the excellence of these stories from a brief mention of their plots. The telling is everything, and the telling (in Chaucer's words and with Chaucer's dry comments on each narrator in turn), is not only great literature but also great fun.

Chaucer died in 1400, and with him ended the Middle Ages in England. For another century or more there was no great writer of his eminence. The only names that may be singled out for special mention are Malory who wrote the stories of King Arthur and his knights (already referred to earlier in the chapter), and Sir Thomas More who wrote *Utopia*.

More's "Utopia"

The word Utopia (meaning nowhere) is used to describe an ideal state or dream country; and one cannot depict such a " heaven on earth " without indirectly criticizing the country in which one lives. The earliest Utopia may have been Plato's *Republic*, but More's book deals with many problems which are still unsolved today. Who, for example, is to do the " dirty work "? (In Utopia it was part of the punishment of criminals.)

There have been many other Utopias—Bacon's *New Atlantis*, Morris's *News from Nowhere*, Butler's *Erewhon*, Wells's *A Modern Utopia*, etc. The word Utopia is

familiar in present-day politics. Sir Thomas More's little masterpiece must certainly be included among the world's great books.

Elizabethan Poetry and Drama

Up to this time, literary geniuses appeared at long intervals, but now there came a glorious period when they seemed to be everywhere in such numbers that (as one writer put it) England became "a nest of singing birds." The influence of the Renaissance was like a quickening spirit throughout the land.

The first important name is that of Edmund Spenser, born in London about 1552 (though he was of Lancashire stock), and in spite of the fact that he was befriended by Sir Walter Raleigh and introduced to the royal court, most of his short life was passed in dire poverty. He has been called the "poets' poet," for a very good reason. His work was an inspiration to many other poets—Milton, Dryden, Keats, Shelley, Tennyson, to name only a few. He is rarely read by the general public; indeed it is said that not one person in half a million has read his greatest poem, *The Faerie Queene*. Nevertheless, the story of Lady Una and the Red Cross Knight is known to most people, as also is Britomart; while most of us are aware that Gloriana signified the queen herself.

The Faerie Queene is a long epic poem, describing the adventures of the knights of Elizabeth's day and their deeds of chivalry. The action takes place in Ireland where Spenser was living at the time—a country full of storm and trouble. He wrote other fine poems, but they may be passed over. Incidentally he gave the world a new pattern in verse, the Spenserian stanza.

After Spenser—the Elizabethan dramatists. They appeared in battalions. Those who prepared the way for Shakespeare were Lyly, Peele, Greene, Lodge, Nashe, Marlowe, Kyd, and others. Shakespeare's prose was influenced by Lyly; his romantic comedies by Peele and Greene; his tragedies by Marlowe and Kyd. He had a large circle of intimate friends who frequently foregathered with him at the Mermaid Tavern—Ben Jonson, Beaumont, Fletcher, Dekker, Chapman, and many more.

Shakespeare

William Shakespeare (1564 to 1616), is, without question, Britain's greatest dramatist. He outsoars his brilliant contemporaries as Mont Blanc overtops the surrounding Alps. It is difficult to write about him without using superlatives stretched to the limit. It is strange that we know so little about his private life. We know that he was born and died in Stratford-on-Avon; that he married Anne Hathaway; that after getting into trouble for poaching and deer-stealing he fled to London; that he worked under Burbage at the Globe Theatre. But whoever, and whatever sort of man he was, we have his plays.

Some people believe that Shakespeare never wrote them, that they were the work of Bacon or of a certain German count; but there is no need to enter that controversy here. When we say Shakespeare we mean the creative mind that gave the world those immortal comedies and tragedies. The usual volume contains thirty-seven, but critics have come to the

conclusion that he did not write everything in the collection. *Titus Andronicus* seems to be the work of another pen, and it is practically certain that the first and last acts of *King Henry VIII* were not his work. In those days the dramatists helped one another, polishing and finishing each other's work, and collaborating generally.

Shakespeare's plots were lifted from all kinds of places like Plutarch's *Lives*, Holinshed's *Chronicles*, Kyd's *The Jew of Malta*, Lodge's *Rosalynde*, and so on. These borrowed plots were to the dramatist what clay is to the potter and a piece of marble to the sculptor. The point is not where he found his material but what he made of it. And there we see his genius at its height.

In addition to being a great dramatic craftsman, Shakespeare was a poet with a power of magic over words. One has only to read the opening lines of *Twelfth Night*, or *A Midsummer Night's Dream* to realize his lyrical gift.

But perhaps his supreme gift was his insight into character and the amazing sweep of his understanding. He can give us all the passion of first love in *Romeo and Juliet*, and he can lay bare the depths of villainy in *Othello* and the tortured soul of a murderer in *Macbeth*. There are dozens of clowns in Shakespeare, but no two are alike. His women are all wonderful—Rosalind, Viola, Sylvia, Miranda, Imogen, Desdemona, Ophelia, Cordelia, Portia, Lady Macbeth. No two are alike, and all are intensely real.

Shakespeare's earliest plays like *A Comedy of Errors* (borrowed from Plautus) and *Love's Labour's Lost* are very artificial in plot and structure. His later plays, like *Hamlet*, *King Lear* and *The Tempest* are more mature--genius at the height of his power. (Why is *The Tempest* given first place in the volume when it was the last play he wrote?)

Critics cannot agree as to which is Shakespeare's greatest work. Some assert that it was the story of the mad old King Lear, but the one which has aroused the loudest argument is undoubtedly *Hamlet*—a play which, acted in its entirety, lasts a full six hours. Yet to those who have been present at such a performance it still seems quite short.

Perhaps *Twelfth Night* may be singled out as the loveliest of the romantic comedies, *Macbeth* as the most fascinating of the tragedies, and *The Tempest* for its philosophy.

The other Elizabethan dramatists are rarely acted nowadays. One can occasionally see Dekker's *Shoemaker's Holiday* or Jonson's *Every Man in His Humour*, but the Elizabethan flavour of these plays prevents their becoming popular with the mass of playgoers. Shakespeare, however, belongs to all time, and he is appreciated abroad —in Russia and in Germany, for example—as warmly as in the land of his birth.

Elizabethan Writers

Some writers of note in Elizabethan England were Sir Walter Raleigh, Sir Philip Sidney, Robert Herrick, John Donne, and Francis Bacon. Bacon's chief works, *The Advancement of Learning*, *The New Atlantis*, and his *Essays*, are well worth reading today. His style was concise, economical, and a great contrast to that of other writers of his age who were inclined to be

diffuse and meandering. Every essay is a model of pithy writing—getting a quart of sense into a pint-pot capacity. He compelled people to think for themselves. He was compared to Moses who saw the Promised Land but was unable to enter into possession.

John Milton

John Milton was born in 1608—five years after the death of Queen Elizabeth. He was a great epic poet and has been compared to Homer and Dante. Many critics consider him second only to Shakespeare himself.

His most famous poem, *Paradise Lost*, is a tremendous work in twelve books, and to get a fair idea of the magnitude of the theme one should read it all at one sitting. It is a religious poem about the revolt of the angels against the Creator, and in passing it tells the whole story of Creation, recounted in order to "justify the ways of God to man."

Satan is the hero of the poem, but there were other devils with him in the conspiracy—Moluch, Belial, Mammon, Lucifer, Beelzebub—and they had millions of followers, all of whom were hurled from heaven into chaos. They planned war (described in Book VI) in a vast hall called Pandemonium.

Milton wrote other great poems: *Paradise Regained*, *Samson Agonistes*, *Comus*, *Lycidas*, but people who have not patience to read the longer poems often enjoy shorter poems like *L'Allegro* and *Il Penseroso* as well as the sonnets and the *Ode on the Morning of Christ's Nativity*. Milton was a Puritan, and for a time was Latin secretary to Oliver Cromwell; but he was not so extreme as many of the later Puritans. He liked music, for example, and there is something about his verse that reminds one of organ music. Also, it is difficult to imagine a Puritan writing:

> Come and trip it as you go
> On the light fantastic toe,

or

> To sport with Amaryllis in the shade
> Or with the tangles of Neaera's hair.

Milton's literary style was dignified, majestic, and weighted with a great many words borrowed from the classics which he loved. He wrote some fine prose, too, the best known being the *Areopagitica*—a speech for liberty of unlicensed printing; in other words, a plea for freedom of expression.

"As good almost kill a man as kill a good book," he wrote; "who kills a man kills a reasonable creature, God's image; but he who destroys a good book kills reason itself. . . . A good book is the precious life-blood of a master spirit, embalmed and treasured up on purpose to a life beyond life."

In his later years Milton, like Homer, was blind; and it is believed that he ruined his eyesight by excessive poring over books and manuscripts. When he could no longer see, his daughters read aloud to him, and his later poems had to be dictated. His *Sonnet on His Blindness* is well known, and it will be recalled that his poem about Samson was probably made more poignant by the story that Samson himself was blinded by his enemies.

Seventeenth-century English Writers

The great Puritan writer, John Bunyan, was born some twenty years after Milton. The two men stand in sharp contrast. Bunyan

was regarded as unlettered and had none of Milton's knowledge of the classics. He wrote mainly in prose, and his vocabulary is simple and devoid of the ponderous Latin words beloved by the poet. Could anything be simpler than the opening sentences of *The Pilgrim's Progress*?

" As I walked through the wilderness of this world, I lighted on a certain place where was a den, and laid me down in that place to sleep: and, as I slept, I dreamed a dream. . . ."

Most people have heard of Bunyan as the tinker of Bedford, and know that he was in prison when he had his famous dream. He was frequently in prison for addressing meetings; in fact, his jailers occasionally let him out to keep an appointment! He was intensely religious. His first book was entitled *Sighs from Hell, or the Cries of a Damned Soul.* We do not read it today, but his *Pilgrim's Progress* is one of the masterpieces of religious literature.

We hear more and more about the Puritans in the seventeenth century. They revolted against the idea that life was given to us merely to enjoy as a sort of comedy: it was a solemn business, a preparation for life hereafter. The underlying idea of Bunyan's great work was a sort of bargain based upon the theme of "No Cross—No Crown." We may dislike his attitude towards life but we cannot help admiring his literary power. His description of Christian's fight with Apollyon is magnificent.

Here another name must be mentioned—that of John Dryden. His relatives were strict Puritans, but when Charles II was restored to the throne, young Dryden became an ardent royalist. He wrote amusing comedies like *Marriage à la Mode* as well as heroic tragedies in verse. He wrote some fine poems, notably *Absalom and Achitophel* and *Alexander's Feast*, and was made Poet Laureate.

Seventeenth-century Britain gave the world some other great writers of prose. Izaak Walton, for example, is remembered for his *Compleat Angler*—a charming work —and Samuel Pepys for his diary. This diary was never intended for publication. It was a secret record of a man's daily life during a few memorable years (including the years of the great plague and the fire of London), and was written in code. The key to it was discovered many years later and the private document published for all the world to read. Pepys was in an important position at the Admiralty and his services were greatly appreciated by the king; but the main part of his diary deals with his flirtations, his new waistcoats, his jealous wife, his visits to the theatre and to church. His diary is a sort of stained-glass window into the life of the century—but Pepys himself was no saint. Still, he was a lovable rascal. . . .

Religious Literature

There were religious writers like Jeremy Taylor, Richard Baxter, Thomas Browne; but much as the twentieth-century reader may disapprove of their doctrines he cannot but admire the style in which they were written. Taylor's *Holy Living and Holy Dying* and Browne's *Religio Medici* are unforgettable. Browne's little book on *Urn-Burial* is also, in its way, a masterpiece.

It is interesting to notice how the

intellectual centre has moved from place to place. Several centuries before Christ, Athens was in the forefront of civilization. After her decline the centre passed to Rome, and later to Constantinople at the eastern end of the Roman Empire in the Middle Ages. But when the Turks conquered Constantinople in 1453, the seats of learning moved to Italy, France, Belgium and Holland; later still to England when the universities of Oxford and Cambridge were established.

During the seventeenth and eighteenth centuries, Paris became the intellectual centre of Europe, and France produced an abundance of great literature.

17th- and 18th-century France

When the influence of the Renaissance began to be felt in France, she set to work to purify her language, seeking to eliminate many bastard foreign words which had crept into use, and making the French language an exact and lucid vehicle for the expression of ideas. The French have always prided themselves on their exactitude and their logic. They have a keen sense of form and admired the classic rules laid down by Aristotle. In drama, for example, they clung to the three "unities," whereas in Spain and England these venerable rules were thrown to the four winds.

The great French dramatists are little known to English theatregoers, but some may remember them rather ruefully because they were made to study them at school. There was Pierre Corneille, for instance, whose most famous play, *Le Cid*, was first performed in Paris in 1636. The theme was borrowed from a Spanish writer and the action takes place in Seville. The subject is intensely dramatic—the conflict that occurs in the heart of the heroine when she falls in love with the man who killed her father and saved the country. The story hinges on the Cid's victory over the Moors. Corneille wrote other plays, but they are all based upon the same fundamental pattern.

Racine's first outstanding play was *Andromaque* (1667), which was followed by *Britannicus*, *Bérénice*, *Phèdre*, and the Old Testament plays, *Esther* and *Athalie*, great tragedies after the classic models.

In striking contrast to these two dramatists was Molière, a busy actor-manager who contrived to write about forty comedies of various types. The best known were *L'École des Femmes*, *Tartuffe*, *L'Avare*, *Le Misanthrope*, *Le Malade Imaginaire*, and *Le Bourgeois Gentilhomme*. The last concerns a certain Monsieur Jourdain who tried to become a gentleman of culture by taking lessons in dancing, music, fencing, philosophy, etc. He is constantly quoted because he expressed such great delight in discovering that he had been talking prose all his life without knowing it! Molière is considered one of the most original comic writers of all time.

Other great writers of this period can only be mentioned in passing—Descartes (the philosopher), Pascal (writer of profound religious works), La Rochefoucauld (famous for his epigrammatic maxims), Boileau (the critic), La Fontaine (known to English pupils for his fables in verse), and Beaumarchais, author of two plays which were made into operas—*The Barber of Seville* and *The Marriage of Figaro*.

Other great French writers of a

Fig. 4. *Voltaire (1694-1778), "The Man, unique in all ages," being crowned by the Marquise de Villette in the theatre. The drawing is after an engraving of 1778, now in the Hennin Collection.*

later period, who deserve more than a passing mention, were Voltaire (see Fig. 4), the cynical author of the *Encyclopédie* and of the fantastic novel, *Candide*, and Rousseau, revolutionary dreamer whose *Contrat Social* inspired the ideals of America as well as his own country—his *Émile* contained new ideas concerning education.

Restoration Dramatists

The Puritan influence was strongest in Britain in the seventeenth century, especially under the rule of Cromwell and his Roundheads, but with the return of Charles II in 1660, the Cavalier element began to reassert itself. Theatre-going was no longer under a ban, and for the first time women were seen on the stage (in Shakespeare's day all the women's parts were taken by young boys).

Instead of the open-air theatre, usually in an inn-yard (see Fig. 5), there came the fully roofed-in building with artificial lights so that people could attend theatres in the evenings. The Puritans stayed away, of course, but the aristocracy followed the example of the Court, and the poorest classes attended for sheer love of a show; but the respectable middle classes had a prejudice against the theatre which lasted through the reign of Queen Victoria. Perhaps they took too literally the notice: "This Way to the Pit."

The Restoration dramatists were witty, and judged by modern standards, inclined to be immoral. Their plays are still revived from time to time in London—comedies like Congreve's *The Way of the World* and *Love for Love*; Farquhar's *The Beaux' Stratagem*, and Wycherley's *The Country Wife*. These comedies of manners, as they

are called, represent one of the most glorious periods of English drama.

After them came a long dreary period, enlightened by only two dramatists of note in the eighteenth century—Sheridan, author of *The School for Scandal* and *The Rivals*, and Goldsmith, whose one outstanding success was *She Stoops to Conquer*. Goldsmith, however, made his name in other fields by his novel, *The Vicar of Wakefield*, his poems like *The Traveller* and *The Deserted Village*, and his innumerable essays.

English Eighteenth-century Prose

The early eighteenth century produced a spate of great essayists including Addison, Steele, and (later on) Goldsmith and Samuel Johnson. Addison's essays in *The Spectator* are often set as examples of what English prose should be at

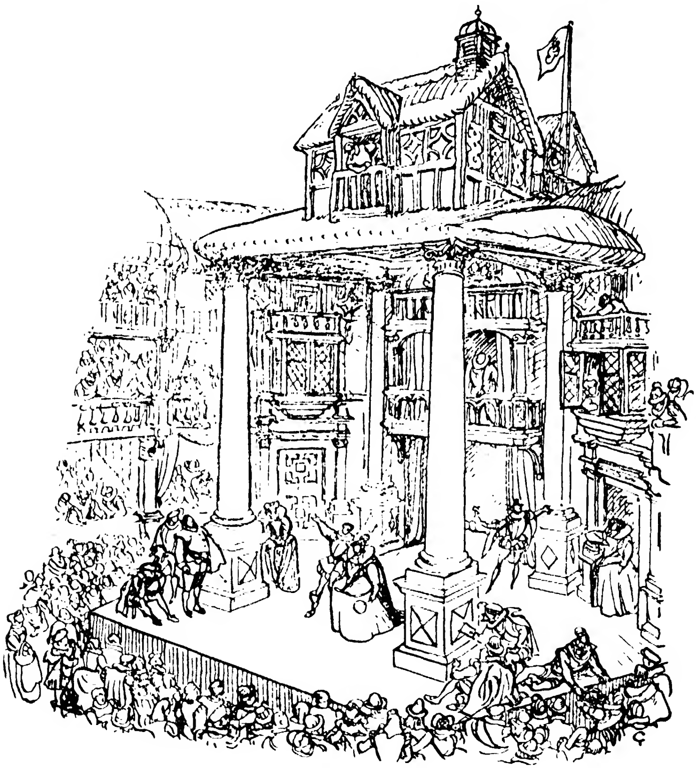


Fig. 5. *A play in progress at an Elizabethan open-air theatre in the yard of an inn. After the Restoration, plays were presented in fully-covered, artificially lit theatres where evening performances could be held.*

its best. They are written in a leisurely style which is characteristic of the age.

But for sheer excellence of style it would be difficult to quote anyone to equal Dean Swift. His famous *Gulliver's Travels* has suffered the same fate as *Don Quixote* in being regarded as an amusing tale for children. On the face of it, that may be true; but there was much more in Gulliver than a humorous tale, and some of the later sections are a savage attack on human nature. For Swift did not love his fellow man. Whether he loved his fellow woman is another subject for controversy, but his letters to "Stella" are memorable.

His *A Tale of a Tub* is a satire on the churches and is rarely read at the present time. His *Hints on Polite Conversation* is rich in sarcasm. The full title is: *A Complete Collection of Genteel and Ingenious Conversation According to the Most Polite Mode and Method, now Used at Court and in the Best Companies of England.* In the introduction he explains that he has listened to the best conversation in fifty of the best families and immediately afterwards written it down in a large notebook. He reproduces the result—and it is terribly banal and cheap. He says:

"I can faithfully assure the reader that there is not one single witty phrase in the whole collection that has not received the stamp and approbation of at least one hundred years. . . ."

But:

"There is one great ornament of discourse, whereof I have not produced a single example. . . ."

He had omitted all the fashionable oaths, he explains, because if he had included them the book would have been at least double the size!

Swift was an Irishman, a Dean of St. Patrick's, who had hopes of becoming a bishop! As old age came upon him he had frequent attacks of giddiness, and once, in talking to a friend, he said: "I shall be like that tree: I shall die at the top." What he foretold came to pass. His brain became overclouded and he died insane at the age of seventy-seven. Joseph Addison pronounced him the greatest genius of the nation.

Johnson and Boswell

In discussing the eighteenth century it is impossible to overlook the towering figure of Dr. Samuel Johnson who was a sort of literary autocrat. He was the central figure of a circle of well-known men—Garrick, the actor; Reynolds, the artist; Goldsmith, the poet; and a number of others including the biographer Boswell.

Johnson wrote essays for *The Rambler*, a novel, *Rasselas* (dashed off in a hurry to pay the expenses of his mother's funeral), *Lives of the Poets*; but he is best remembered as the man who, single-handed, compiled the famous dictionary. We do not use that dictionary today, but he was the pioneer of lexicographers and laid the foundations for his successors.

Curiously enough, Johnson's fame rested mainly on the biography of him written by his friend Boswell. Boswell's *Life of Johnson* and Lockhart's *Life of Scott*, are probably regarded as the two best biographies in the English language. Boswell did what Swift pretended to do: he made notes of the conversations he had listened to and retailed them in his book. These

actual examples of Johnson's style of speech, of his opinions on a thousand subjects of contemporary interest, and of his fierce attacks on anyone and anything with which he did not agree, have made the personality of the great Johnson survive when the mass of his writings has been neglected or forgotten.

Other important figures of this eighteenth century include Daniel Defoe (see Fig. 6), author of many books, the best of which is *Robinson Crusoe*; Gibbon, the historian, whose *Decline and Fall of the Roman Empire* is a classic; Burke, the statesman, whose chief work was his *Reflections on the French Revolution*. But of much greater significance is the fact that it was in this period that the English novel first came into being as a new form of literary art.

The Early Novelists

There are sometimes arguments as to which was the first English novel, but it is generally conceded to be Richardson's *Pamela, or Virtue Rewarded*. That book made a tremendous sensation, not only in England but in France also. It is written in the form of a series of long letters by Pamela, a servant girl who appeared to spend her time in defending her honour against a seductive employer in the upper classes. She triumphed, of course, and gained her reward at the altar. The moral of the story is that it pays to be virtuous. It won the whole-hearted approbation of the middle classes who presented it to their daughters, and the fact that the scoundrel belonged to the aristocracy squared with their ideas. Richardson's second novel, *Clarissa Harlowe*, was about another heroine who was not so successful as Pamela. Her end was tragic.

Richardson had an immense fan-mail, and women of all ages wrote to him to express their admiration or to seek his advice. He probably loved it all. But men had little time for him: they found him a pretentious bore.

A far greater man was Henry Fielding whose *Tom Jones* is a really great novel. It is verbose and garrulous by modern standards, but it is still one of the world's masterpieces of fiction. Fielding's *Joseph Andrews* is a skit on *Pamela* and describes the virtuous coachman's struggles against a designing mistress.

Two other big names in fiction: Smollett, author of *Roderick Random*, *Peregrine Pickle*, etc., and Laurence Sterne, author of the somewhat shocking *Tristram Shandy*, and *The Sentimental Journey*. *Tristram Shandy* is rich in humour of character and incident; Uncle Toby and Widow Wadman are great creations. *The Sentimental Journey* is hardly deserving of its reputation.

But English fiction has made a vigorous beginning, and we must return to it a little later.

Eighteenth-century Poets

The eighteenth century produced many poets, and they (like the essayists) aimed at a kind of perfection which is not always inspiring. They kept strictly to the metre and their rhymes rang true, but somehow the poetry seemed to be artificial and out of touch with reality. Verse was something special and precious. Pope, Dryden, Goldsmith, Gray, Thompson and Cowper, were all of this period. So also were the less classically

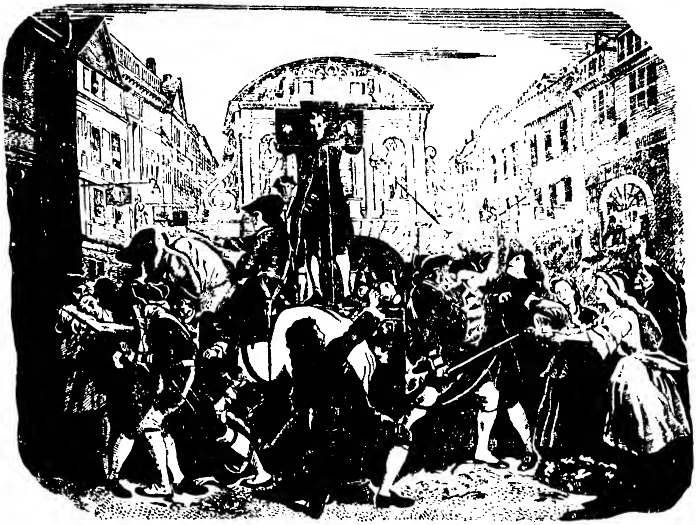


Fig. 6. *Daniel Defoe (c. 1659-1731), author of many books, including the famous "Robinson Crusoe," pilloried for his sectarian activities. This drawing, after a painting by Eyre Crow, illustrates Defoe's popularity with the masses; instead of throwing rotten eggs at him, as was the custom of that time, the people fed him with good food on sticks.*

minded Blake—that artist and mystic who cannot be put into any convenient pigeonhole—and "Caledonia's Bard," Robert Burns, who always wrote just as he felt without making any attempt to imitate the perfect models.

The Romantic Revival

At the end of the century came a revolt known as the Romantic Revival. It was headed by Wordsworth and Coleridge, aided and abetted by Shelley (see Fig. 7), Keats and Byron. Wordsworth believed that poetry should be written in the common language of every day. If he wanted to write of country lovers he called them country lovers—not rural swains (as Pope would have done) and they would go wandering under the trees—not in the grove.

Wordsworth wrote some magnificent poetry like *Intimations of Immortality*, *Tintern Abbey*, and some sonnets. His *Prelude* sounded a new note. But the trouble about Wordsworth was caused because he never seemed to know when he was writing great poetry and when he was writing dreary rubbish. He was noted for his profound love of nature and simple things. Coleridge on the other hand was much inclined towards the supernatural. His *Ancient Mariner* is a weirdly beautiful and moving story; his *Christabel* has some lovely lines; but what is perhaps his most inspired poem is only a fragment, *Kubla Khan*, which was composed

in a dream and, fortunately, recollected on waking.

Other poets of this period were Scott and Matthew Arnold. Scott wrote long poems like *The Lady of the Lake* and *Marmion*, but when he found that public opinion put Byron first and himself second he gave up writing verse and began to write the Waverley novels in which he had the indisputable first place. Matthew Arnold was the son of the great Arnold of Rugby, the headmaster of the school described in *Tom Brown's Schooldays*. One of his finest poems, *Rugby Chapel*, is a tribute to his father's memory.

There were many fine poets such as Rossetti, Morris, Swinburne, Elizabeth Barrett, Yeats, and Housman, during the later part of the nineteenth century, but two of the most outstanding names were those of Tennyson and Browning. Tennyson was enormously popular, and his greatest works were *In Memoriam*, *Maud*, *Idylls of the King* (the legends of King Arthur), and a number of battle poems like *The Revenge*.

Browning's poems often lacked the singing melodies and jewelled phrases of Tennyson, but his thought went deeper. In many ways he was superior to Tennyson, but he was never a popular poet as the Laureate was. He eloped with Elizabeth Barrett to escape from her tyrannical father, and lived many years in Italy.

Nineteenth-century Fiction

The novel continued to wax strong throughout the nineteenth century and is still the most widely read form of literature. At the

Fig. 7. *Shelley in Rome, after a painting by Joseph Severn.*

beginning of the period Sir Walter Scott was turning out novel after novel, working at a furious rate in an attempt to pay his debts. For many years he held the country under a spell of enchantment, but his popularity has waned in recent years. It must be confessed that his historical knowledge is far from reliable, and that he wrote with careless haste. Arnold Bennett said that the Waverley novels were "just chucked together." But to Scott belongs the honour of creating a new kind of fiction—the historical novel keyed to romance.

Women Writers

A contemporary of Scott, Jane Austen, wrote little and with great care. She found all her subjects in the quiet life of her home town and the personalities she met in the drawing-rooms. Readers who have never sampled her work would be well advised to start with *Pride and Prejudice*—they will want to read the others. There were other fine women writers, George Eliot, Charlotte Brontë, her sister Emily, and Mrs. Gaskell. George Eliot was the greatest—a woman with a masculine mind—author of *Adam Bede* and *Middlemarch.*

The Reformer Novelists

The nineteenth century was a time of great social unrest, and it is not surprising that so many writers were filled with reforming zeal. The most outstanding was Dickens who saw so many injustices in the world and burned with a desire to set them right. Even in a great masterpiece of humour like *The Pickwick Papers* he attacked the bribery at elections and the loathsome Fleet prison. In *Oliver Twist* he went for the workhouse system and the general bullying of the poor; in *Nicholas Nickleby* he attacked the schools run by brutes like Squeers; in *Little Dorrit* he attacked the debtors' prison—the infamous Marshalsea; in *Bleak House* he attacked the administration of the law. Dickens was a great humanitarian who used his gift of humour to some purpose. He was also possessed of a supreme power of creating character. Some of his characters have become household words: Mr. Micawber, Mr. Pickwick, Sam Weller, Scrooge, Quilp, Mrs. Gamp, Betsey Trotwood, and many more. He failed only when he tried to create a heroine. One has only to compare Little Nell or Agnes Wickfield with the heroines of Scott, like Diana Vernon, or Lucy the Bride of Lammermoor.

Charles Reade was a reformer when he wrote *Hard Cash*, but not when he wrote *The Cloister and the Hearth*—a glorious historical novel of the Middle Ages. Charles Kingsley was a reformer when he wrote *Yeast*, but not when he wrote his *Hereward the Wake* and *Westward Ho!*

Thackeray and Trollope have a more detached attitude to life. Thackeray's best work was *Vanity Fair* and *Henry Esmond*; Trollope's novels of clerical life in Barchester were forgotten for a long while, but have been returning to favour in recent years.

The Great Cavalcade

But it is impossible to do the scantest justice to the spate of fiction. Meredith and Hardy reached greater heights than most of their contemporaries, but Meredith is little read today and Hardy is sometimes dismissed because his

stories often end in tragedy. *Far From the Madding Crowd* and *Tess of the D'Urbervilles* were among his best.

Apart from fiction, the nineteenth century produced historians like T. B. Macaulay and Thomas Carlyle, scientists like Darwin and Huxley, essayists like Lamb, Stevenson and Pater, critics like Ruskin, logicians like Mill, religious writers like Newman, and a host of others.

In the twentieth century Britain has had some fine novelists. Among those who have passed away within recent years certain names may be singled out for special mention: Arnold Bennett, Joseph Conrad, John Galsworthy, George Moore, H. G. Wells, and James Joyce.

Nineteenth-century French Literature

It is quite impossible to do justice to the prominent figures in France. Dumas had a great admiration for Scott and followed his lead in writing historical romance. His *Three Musketeers* and *The Count of Monte Cristo* are very popular in Britain. Victor Hugo might be compared to Dickens, especially in his best-known novel, *Les Misérables*, and also in *The Hunchback of Notre Dame*. Balzac, author of nearly a hundred novels like *Père Goriot*, *Eugénie Grandet*, and *Le Peau de Chagrin*, tended to break away from the severely classical ideals and the addiction to preciosity, and brought literature more into line with the sort of French appreciated by the "man in the boulevard." His skill in the depiction of French character in all grades of society was another reason for his immense popularity with the ordinary reader.

In the eighteenth century French authors had a great reverence for form and style, clinging to the classic ideals. But in the last few years of the century the French Revolution took place and was followed by a dull period in the literature of the country. There was a similar tendency to break away from the classic to the romantic as seen in England.

Several names are outstanding at the beginning of the nineteenth century—Madame de Staël, who was an intellectual and pronounced classicism to be obsolete, Chateaubriand who defended the Christian religion against the rationalism of the period, and several lyric poets. The best known of these were Lamartine, Alfred de Vigny, Victor Hugo, and Alfred de Musset.

Of later prose writers two of exceptional importance were Flaubert, whose *Madame Bovary* is considered one of the world's masterpieces, and Daudet who wrote *Tartarin de Tarascon*. The short stories of Maupassant were perfect cameos of literary art.

There are scores of other big names—Stendhal, Loti, Mérimée, Proust, Zola—but their works are less famous outside their native country. We think of Anatole France as a great satirist, and Zola as an uncompromising realist, but the more recent tendencies in France have been in the direction of psychological studies of character. Proust and Gide explored the depths of the unconscious as has been done by Virginia Woolf and Dorothy Richardson in Britain.

German Literature

So far we have said nothing whatever about the literature of Germany, but, unless we count Martin Luther and the cobbler-

poet, Hans Sachs, there was little of outstanding merit until fairly recent times.

Her finest period was round about the opening of the nineteenth century and the greatest name was that of Goethe, author of *Faust*, which is best known in its operatic form. He was a great poet and has an international reputation. Other important writers were philosophers like Lessing, Schopenhauer and Hegel, poets like Heine and Schiller, dramatists like Hauptmann and Sudermann, and today we are aware of the novelist, Thomas Mann.

Russian Writers

Russia had no literature of significance until the nineteenth century, but since the revolution of 1916, she has begun to create at a great rate, though her achievements are still little known outside her boundaries. Before this time there were several names of first importance, particularly Tolstoy, Dostoievski, Turgenev, Gogol, Pushkin, Chekhov, Gorki.

Tolstoy's *War and Peace* and *Anna Karenina* are classed among the great novels of the world. His other works like *Resurrection* and *The Kreutzer Sonata* are second-rate. The last named is the screech of a fanatic. Dostoievski's best works are *Crime and Punishment* (a murder story written with intense power), *The Brothers Karamazov*, and *The Idiot*—faintly reminiscent of Thackeray's *The Newcomes*. Turgenev's *Virgin Soil* is an unmistakable masterpiece, and so is Gogol's *Dead Souls*.

Chekhov was a great dramatist who deliberately aimed at being unmelodramatic and made his characters drift in and out of a room as they do in real life. *The Cherry Orchard* and *The Seagull* are typical examples of his work.

Scandinavian Literature

In Scandinavia, the foremost name is that of Ibsen, the Norwegian dramatist, who dragged real life problems on the stage and had no time whatever for the artificialities of the theatre in other countries. Ibsen's poetic drama, *Brand*, is little known, perhaps, but *Peer Gynt* has an international reputation in its operatic form. His social plays, written in prose, attack conventional ideas and ideals and when they were first produced in England the author was denounced as immoral. One critic described *Ghosts* as an open sewer! They are judged by different standards today, but in Victorian days they were a shock to British feeling for good taste. The most widely known are *The Wild Duck*, *A Doll's House*, *The Master Builder* and *Pillars of Society*. Ibsen's influence was profound, and deeply affected the British dramatists, Pinero, H. A. Jones and Shaw.

Strindberg, the Swedish dramatist, is less appreciated and it is doubtful whether his plays can be reckoned among masterpieces, although *The Father* created a temporary sensation.

Among other Scandinavians of note the Danish writers, Hans Andersen, author of children's fairy stories, and Georg Brandt, the critic, may be mentioned.

The American Contribution

American authors produced little of permanent importance until the beginning of the twentieth century. Today, in drama, novels, and short stories, the American contribution

to world literature is perhaps second to none.

In the nineteenth century there were the American poets like Longfellow, Lowell, Whittier and Walt Whitman (see Fig. 8); but with the exception of the last named, the work was largely imitative. Longfellow was a weaker edition of Tennyson, for instance. Their novelists were popular — Fenimore Cooper, Nathaniel Hawthorne, Bret Harte, Harriet Beecher Stowe, Louisa Alcott, and a score of others. Hawthorne's *The Scarlet Letter* was a notable achievement, but the rest matter little today. Of greater significance were Edgar Allan Poe, who was a master of the art of the uncanny short story and the originator of the private detective as hero; Whyte-Melville, who wrote *Moby Dick*; and the humorist, Mark Twain, author of *Tom Sawyer* and *Huckleberry Finn.*

Fig. 8. *Walt Whitman (1819-1892), a virile and original American poet, known to many as being essentially a "child of nature."*

Among critics, essayists, writers of belles-lettres, we should remember Thoreau, Emerson, and Oliver Wendell Holmes, author of the charming *Breakfast Table* series. But America gave the world two historians who come within the first class along with Gibbon, Carlyle, Mommsen, Grote, etc. They are Prescott whose *Conquest of Mexico* and *Conquest of Peru* are fascinating as any work of fiction, and Motley, author of *The Rise and Fall of the Dutch Republic.*

Names of living writers have been avoided as far as possible throughout this chapter, but in order to give a fair impression of America's contributions to literature it is necessary to mention a few men and women who are doing original work of high importance. Among present-day dramatists, for example, no names stand higher than Eugene O'Neill (author of *Mourning Becomes Electra, Strange Interlude*, etc.); Elmer Rice (author of *Street Scene, Counsellor at Law*, etc.); Maxwell Anderson, George Kaufmann, Marc Connelly, Philip Barry, and Paul Green.

In the field of fiction, too, there are a number of outstanding names —so many that it is not possible to select particular ones for mention without doing injustice to others who ought to be described in detail. One name, however, may perhaps be given: that of Sinclair Lewis, author of ***Babbitt*, *Main Street*, *Martin Arrowsmith*,** and other books about American life.

CHAPTER 13

OUTLINE OF MUSIC

Classical and popular music. Purpose of music. Programme music. Materials of music. Musical forms. The piano. Style in music. The orchestra. Chamber music. Opera. Oratorio and cantata. Madrigal and motet. Song composers. Classical period. Romantic movement. Impressionism in music. Modern music. Musical masterpieces.

At least one reliable dictionary defines music as "melody and harmony; a succession of sounds so modulated as to please the ear." Now that doesn't get us very far because we immediately want to know whose ear is to be pleased: yours, mine, Duke Ellington's, Beethoven's (Beethoven was deaf, by the way!), or those of the famous judge who said he couldn't tell the difference between God Save the King and Rule, Britannia! The point is that there's no such thing as *the* ear. Ears are not standardized like needles or a particular make of car. The sense of hearing varies among individuals as do the senses of sight, smell, and taste.

Another reliable dictionary tells us that music is "the art of combining sounds with a view to beauty of form and expression of emotion." Well, we have all listened to a lot of music, most of it by dry-as-dust old professors, which achieves a certain beauty of form but is without emotional appeal. On the other hand we all know the kind of song churned out by Tin Pan Alley and sung by crooners which has no beauty of form, but is full of emotion.

So we see that the term "music" is vague and elusive: it can mean many different things to as many different people. There is a world of difference between the music of an Indian ceremonial dance and a Beethoven Symphony, or a crooner's song and a Wagner opera.

In this article, however, we are concerned mostly with what is commonly called classical music. It can range from a simple and charming little song like Schubert's Ave Maria to a profound, complex, and soul-stirring work like Brahms's Fourth Symphony.

Many people who are not attracted by classical music—or rather think they are not—want to know why all this highbrow stuff should be superior to the other kind of music—swing, jazz, or musical comedy, which the majority of people prefer. Unfortunately, the majority of people prefer their amusements and entertainments to be of a kind that require neither physical nor mental effort. That is why chess is not a popular game and why the majority of men prefer to watch a game of professional football rather than play themselves as amateurs.

The classical-music lover knows that his kind of music is superior to other kinds of music because it has

a spiritual and intellectual appeal as well as an appeal to the deeper emotions. The so-called popular music of today, like so many other things, is synthetic. It is turned out mechanically from ingredients that are specially selected to titillate the kind of ear which hears but does not listen. Commercial music of this kind, like the commercial film and novel, must conform to a set formula and pattern. Those who bring thought as well as feeling to their listening, viewing, or reading see through these cheap devices and are sickened by their synthetic qualities and monotonous repetitions.

Nevertheless, even though a person may be infatuated with crooning or what we may call synthetic music from Tin Pan Alley, he can quite easily transfer his interest and affections to music that is really worth while, if he takes a little trouble and uses his head as well as his heart.

Swing and Jazz

While on the subject of popular music it might be worth while to describe the essential characteristics of swing and jazz, upon which few people seem to be clear. Both modern dance music and swing derive from jazz, which was the first in the field. Its history goes back to just before the First World War when America became interested in negro musicians who had evolved a unique style of playing of their own.

Most of these musicians did not read music, but by means of natural musical gifts they acquired a technique of playing various musical instruments (such as the trumpet, trombone, and saxophone) that was outstanding in its brilliant virtuosity. They would take a tune—more often than not of negro origin—and improvise upon it, usually in the form of an eight-bar blues, with great skill and richness of arabesque and decoration.

A distinctive feature, of course, of these improvisations was the exploitation of syncopated rhythms and the necessity to keep to a fundamental beat of four-in-a-bar. This became known as jazz and later many of its elements, particularly syncopation, became absorbed in dance music.

Swing is a comparatively recent term. It applies to a kind of jazz which is not improvised but played from written parts. It is often the work of very clever and ingenious "arrangers" who know how to get the utmost effect out of a large orchestra (pure jazz, of course, is and can only be played by a small number, rarely more than six solo players). But both swing and jazz are of necessity very limited for, apart from anything else, it seems impossible for these styles to get away from the monotonous four-in-a-bar rhythm and a certain stereotyped harmonic scheme.

Classical Music

In classical music, however, compared with swing and jazz, the possibilities of varied harmonic colour and subtleties of rhythm are almost unlimited. The appreciation of classical music is by no means the pursuit of an intellectual. It has nothing to do with profound learning; it is merely a matter of good taste. Of course, there is nothing criminal in liking music that is crooned and swung, any more than it is criminal to prefer imitation jewels to real jewels or

synthetic jam to home-made jam. But whereas today the best quality in material things costs more money than most of us can afford, the best music costs us nothing—well, in Great Britain no more than a few shillings a year for a radio licence.

Once anyone becomes really interested in classical music he relegates other kinds of music to their proper place in the background. In other words, he hears that music but he does not listen to it intently, as he would to classical music. Classical music will open up a new world that will satisfy you from every point of view—emotionally and spiritually, and intellectually if you will. It is something of which it is impossible to tire; it becomes a part of your normal experience and is as necessary as food or drink.

The Purpose of Music

What is the purpose of music? We are often assured that "music must teach," and therefore music is not an end in itself but a means to an end—the end is to express philosophical, religious, or political truths. This, of course, is quite untrue as it is impossible to produce a piece of music that describes in terms of pure sound such things as Plato's theory of ideas, or the equity of free trade.

Granted that a piece of music can be turned into a symbol of any of these ideas, but the musical values still remain unaffected. There is no reason why a slab of concrete should not be made the symbol of a slab of chocolate and the result will no doubt pass every test of the imagination, but it would obviously be unwise to eat it.

A composer is, of course, influenced by his social, economic, and intellectual environments, which provide him with the necessary stimulus to create and to express himself. But what he creates is the result of the stimulus and not necessarily an interpretation or translation of it. Music is not emotional in itself: the emotion comes from the listener—it is the personal reaction to musical sound. Definite emotional suggestion in music is therefore largely a matter of association. It is surprising how many music-lovers confuse what music can do with what music is.

Thus, it is the music that matters, whether the composer intends it to symbolize or to depict a world revolution, an express train, or a sweet young thing tripping through the meadows picking dandelions. As mentioned previously, any music that requires a literary interpretation to be understood is bad music.

A knowledge of Shakespeare's *Romeo and Juliet* will not make the music of Tchaikovsky's overture sound more beautiful. What added enjoyment may be obtained from listening to Tchaikovsky with Shakespeare in mind is non-musical. The vase cannot affect the essential beauty of the rose, nor the frame the essential beauty of the picture.

On the other hand, there is nothing wrong in a composer writing a piece of music to illustrate a story or poetic idea. It is merely wrong to judge music on non-musical grounds, and to invent a programme to, say, a Beethoven quartet where none was intended.

Programme Music

Story-telling in music is called programme music, and programme music is a legitimate style of composition. When a composer writes

in this style, a knowledge of his intentions certainly adds to the general effect, but no music worthy of the name relies on a story to make clear its meaning. Literature and painting are much more efficient vehicles for telling a story than music; music should be listened to for its own natural beauties. One does not ask the meaning of a beautiful landscape, therefore why ask the meaning of a beautiful pattern of musical sounds?

Materials of Music

Every art is conditioned and limited by the materials it uses. The sculptor works with stone, the painter with canvas and colours, the poet with words, and the musician with sound. All the arts excepting music have for their subject matter concrete things and ideas related to every-day experiences. But the subject matter of music is sound, which is an abstract material. Musical sound broken up into its component parts consists of melody, rhythm, harmony, colour and form.

The basis of all European music from the very beginning up to the present day is melody. One might ask the question here: what is a good or a bad melody? Many learned musicologists have attempted to analyse the characteristics of a good melody and those of a bad melody, but they have met with little success because the many exceptions disprove the rule. The test of a good melody would appear to be that it lives through the ages, that is to say that the majority of people in each generation continue to play, sing, or whistle a certain tune. We all know that Annie Laurie and The Londonderry Air are fine melodies and that the vast majority of the popular tunes of today are not, because scarcely anyone wants to hear the majority of the popular tunes again after they have reached the end of their short life of a few months.

The importance of melody in classical music is not so much in the quality of the tune itself, but what the composer makes out of it in the course of his composition. Thus there are melodies that can be sung, such as the famous tune in the first movement of Schubert's Unfinished Symphony, and there are melodies that rely on their treatment for their full significance —for instance, the well-known rat-a-tat-tat, or postman's knock, theme in the first movement of Beethoven's Fifth Symphony, which is more a rhythmic *motif* than what we might call a tune for singing.

Every period in the history of music has had its own ideal of melody. In the early times of the troubadours and minstrels, before large choirs and orchestras came into existence, music was confined to melody alone—that is to say, one melodic line without any harmony to support it. Eventually, however, this kind of music became monotonous, and composers relieved the monotony by singing the same tune simultaneously at intervals of an octave, a fourth, or a fifth above or below it. Still more variety of sound was added when two different or independent melodies were sung at the same time, and thus was born the art of counterpoint, or polyphony.

Rhythm

The most important ingredient of melody is, of course, rhythm. There is no such thing as melody without rhythm, but there can be

rhythm without melody. There are two types of rhythm: restricted and free. Restricted rhythm is tied to what we call the bar line, which means that a tune is divided up into equal lengths beginning with a strong beat. Any march or waltz tune gives a perfect example of restricted rhythm. Free rhythm is much more subtle and difficult to explain. Free rhythm was the characteristic of all music up to the sixteenth century, before the bar line was invented. Its distinctive qualities are registered mentally rather than by tapping with the fingers or the feet. To hear the difference, it is well worth making a special point of listening to a broadcast programme of Elizabethan madrigals or early church music (plainsong).

Harmony

In the sixteenth century the art of polyphony, or combining melodies, in vocal music was carried to an incredible state of ingenuity. It was nothing for a composer to write a piece of music in eight or even sixteen different parts—in other words, eight or sixteen different melodies were being sung at the same time. It is obvious that the combining of a number of tunes produced the simultaneous sounding of a number of notes at any one given moment. This combining of notes, or rather tones, produced what is now called harmony and composers began to alter their style of composition. Instead of writing a piece of music in which melody was set against melody they wrote one tune and supported it with blocks of harmony, or chords. By the eighteenth century harmony began to be accepted for its own expressive and colourful qualities and not merely as a haphazard result of combining various tunes. The extraordinary difference in style between polyphonic music and harmonic music is best shown in the comparison of, let us say, a school class singing Three Blind Mice and a pianist playing Rachmaninoff's Prelude in C sharp minor.

Musical Colour

Colour is a term we all frequently use when writing and talking about music. The essence of colour in music is contrast in sound, which consists of three elements tonality (key), harmony, and timbre.

The feeling for and recognition of key colour is the most subtle and elusive element of the three, for it is largely a matter of personal feeling based on a highly-trained ear.

Harmonic colour is produced by the selection, combination, and contrast of chords. Here are some obvious examples picked at random which are often broadcast: the opening of Mendelssohn's Overture *A Midsummer Night's Dream*, Mozart's Overture *Don Giovanni*, Wagner's Prelude to *Tristan and Isolde*, Chopin's Prelude in C minor (see Fig. 1), Elgar's Introduction and Allegro for Strings, and Debussy's String Quartet.

Timbre or tone colour is produced by the combination and contrast of the various instruments of the orchestra and therefore it is often closely bound up with harmonic colour. In the orchestral music of Debussy and Delius, for instance, the harmonic colour and the tone colour are inseparable. An example of tone colour in its simplest terms is the notes C-E-G-C played as a chord on the piano, then

played by a string quartet, and finally sung by four voices. The chord is exactly the same in each instance, but the timbre or tone colour is quite different.

Form in Music

Form in music is as necessary as form in any other of the arts. The essential characteristics of form are balance and proportion. The human body, the apple, the table, and the chair, under normal conditions are perfectly balanced and proportioned. So with music. "Form," says Dr. Percy Scholes in *The Oxford Companion to Music*, "is one of the composer's chief means of averting the boredom of his audience. If he possesses the power of spinning out shapely melody, as a spider spins out thread, he has one such means, and perhaps the most fundamental one of all. To this may be added the gift of rhythmic subtlety, enabling him to add significance to his melody, and that of harmonic aptness, enabling him to colour it beautifully—both of which increase his chances of commanding and retaining attention. But the application of all these gifts must be according to some principle of form, or his audience will soon be yawning."

All music, whatever its style, must have form. Even the most synthetic dance tune of today has its form, although, of course, of the simplest and most stereotyped kind. Furthermore its harmony is confined to less than a handful of elementary chords and its rhythm is as obvious as that of an ordinary march. That is why musicians are so bored when listening to ordinary synthetic dance music. Music that is to claim the serious attention of intelligent people must contain plenty of variety in treatment and development as well as repetition. There is no virtue in simplicity for its own sake; nor, for that matter, in complexity. They both have their places in the ultimate scheme of things. Nevertheless there is a wealth of difference between The Londonderry Air and I Love My Baby, and My Baby Loves Me—the difference between a natural violet and one made out of Cellophane.

It is obvious that the shorter a piece of music the simpler is its form. History shows that musical compositions have tended to become longer and therefore more complex. Up to the sixteenth century five minutes was the limit of an instrumental work. The average length of a symphony in the eighteenth century was twenty-four minutes; Beethoven extended his symphonies to a length averaging thirty-seven minutes; Brahms's symphonies average forty minutes; while Elgar's go to forty-one; finally, Mahler's Symphony No. 8 lasts over an hour!

Basic Musical Forms

There are six basic musical forms: two-part (binary), three-part (ternary), first movement or sonata form, rondo, air with variations, fugue.

A piece of music in *two-part form* falls into two sections, A and B, which are based on the same melodic ideas but contrasted in key. This was the favourite form used by seventeenth and eighteenth century composers in their instrumental music, songs, and hymn tunes.

Three-part form is more elaborate and varied in its appeal, for it

Fig. 1. *Frédéric François Chopin, Polish composer (1810-1849).*

consists of three clear-cut sections, A-B-A^2. A has its own tune and is self-contained; B has also its own tune in a new related key and is self-contained; A is then repeated to round off the composition. The minuet and trio movements in the symphonies of Haydn and Mozart are all cast in three-part form, which became largely used by composers from the later part of the eighteenth century onwards to the present day. It has become a favourite form for songs and short piano pieces.

Sonata-form is an extension and elaboration of three-part form. It is perhaps the most highly organized form in musical composition. Reduced to its simplest design as used by the early classical masters, such as Haydn and Mozart, who invented and perfected sonata-form, it is this: A (first tune leading to second tune in a contrasted key), B (development of either or both of these tunes), A^2 (first tune repeated and followed by second tune, this time transposed into the same key as the first tune), and finally a coda or ending.

That is the basic idea of sonata-form, but in actual practice each composer elaborates and extends in a hundred different ways to suit his musical purposes. Sonata-form is a free rather than strict form. In fact, it is more a style than a form.

The *rondo* is also an extension of three-part form, in which new episodes are added alternating with the repetition of A. Thus—A-B-A^2 C-A^3-D-A^4. There is no elaborate development of tunes as in sonata-form.

Air or *theme with variations* has always been a form that has attracted composers, for it has infinite possibilities. Variation form is the equivalent of the essay in literature. Just as Charles Lamb or Robert Lynd will take some random topic and toy with it in words for the sheer amusement of it, so the skilled composer will take a theme—his own or someone else's—and use it as a thread on which to string a whole series of musical beads. If he knows his job—and most of the great masters have done some of their best work in the genre—he gives the listener double pleasure: pleasure in the music for its own sake, and pleasure in spotting the connexion with the theme from which it derives.

Perhaps the most difficult form to explain to the uninitiated is the *fugue*, which is as strict in its underlying principles as the sonnet in poetry. The fugue, which is of vocal derivation, is essentially a contrapuntal form, that is to say it is concerned with the interweaving of melodies. Thus the greatest days of the fugue were when

counterpoint was the basis of all music, and it reached its zenith in the music of Bach. The fugue, however, has remained a popular form among composers of all later periods, including those of today.

"A fugue is a composition in which one voice runs away from the others and the hearer from them all," said a wit. The course and functions of a fugue cannot be described in detail here. It may be defined as a composition in which one melodic idea, or voice as it is often called, is contrasted with other ideas. A composition in fugue form grows naturally out of the opening melodic idea which is repeated in turn by the other voices according to the number of parts—two-part fugue, three-part, four-part, etc. These ideas are then treated in a certain prescribed manner, which gives every opportunity for a composer to display his ingenuity. Despite the fact that the fugue is the most artificial of musical forms and has a deep intellectual appeal, the great composers have used it as a vehicle for expressing some of their profoundest emotions.

These six forms, as mentioned previously, are the six basic musical forms. The most important form used for all the varied kinds of instrumental music which flourished after the eighteenth century is sonata-form. Sonata-form is closely allied to the concerto, symphony, and sonata, which developed together during the second half of the eighteenth century.

The Sonata

The *sonata* is written for either one or two instruments: a solo piano (occasionally a solo violin or 'cello) or piano and violin, piano and 'cello, piano and clarinet, and so on. It consists usually of three or four contrasted movements, of which at least one movement (often the first) is designed in sonata-form. The second movement is usually an expressive slow movement (in, say, three-part form, variation-form, or sonata-form). The third movement is a graceful minuet and trio, or from Beethoven onwards a scherzo (literally "joke"), which is in a brilliant and sometimes humorous style deriving in form from the minuet. The fourth movement, called the finale, may be in rondo or sonata-form or may be in the form of variations.

The Symphony

The *symphony* is really a sonata for orchestra. No word in the vocabulary of music is more loosely used and misunderstood than the word symphony. Many listeners use the word in its archaic sense of "harmony" or "consonance of sounds." Originally it did mean "sounding together," and up to the time of Haydn and Mozart various kinds of compositions written for a number of instruments were called symphonies. But from that time onwards, owing largely to the innovations of Haydn and Mozart, symphony became the term for an orchestral sonata.

As time went on it was natural that the form became extremely stereotyped and the academics began to look upon the design of a symphony as a formula rather than a living form. Beethoven brought the classical symphony to its highest stage of development by breaking most of the mechanical rules of his academic predecessors and contemporaries. He, of course, suffered derision for his daring

innovations, but new ideas in art as well as life are always bitterly opposed by the hidebound and the intellectually moribund.

The academic view of musical form, unfortunately, persists in some quarters to this day. And professors still adjust their spectacles on their long and serious noses and measure a new symphony with the tape-rule of the past, and if it does not largely conform to textbook regulations it is dismissed as another example of "modern ineptitude."

After Beethoven the symphony received new impetus from the romantic composers, and there was a strong reaction against the writing of stereotyped symphonies. Berlioz made his symphonies tell a story, as in his Fantastic Symphony, and he introduced a "fixed idea," a theme or motive that runs through the entire work and is modified according to the literary ideas or programme which the music sets out to illustrate. And furthermore the design of the actual symphony was dictated by the events he wished to illustrate. A little later came Liszt who developed this romantic conception of the symphony on very elaborate and original lines. His *Faust* Symphony, for instance, is more like a giant symphonic poem and bears little relation to what we call the "classical" symphony.

Other composers, such as Franck and Tchaikovsky, adapted the symphony to their own peculiar needs—to exploit a philosophic rather than a literary programme.

The chief aim of later nineteenth-century composers and those of the present century was to create either in movements or in whole symphonies a musical organism that grows naturally and inevitably from their initial themes, which is a very different conception of musical form from that of the classical masters. The symphonies of Sibelius and Borodin are admirable examples of this tendency.

The classical conception of the symphony was carried on by Mendelssohn. Then came Brahms who founded his style of symphonic writing on Mendelssohn and Beethoven, ignoring the innovations of his romantic contemporaries. His four symphonies show the magnitude of his genius to the full, and within the austere limitations of his art, he showed an individuality of thought and power of expression that only the greatest masters of music have equalled.

The Concerto and Other Forms

The *concerto* is a sonata for one or more solo instruments with orchestral accompaniment. The original meaning of the term concerto was to denote a piece of music to be played by several instruments together, and therefore there was little difference between early concertos and early symphonies. Corelli, Bach, and Handel wrote concertos for string orchestra with special parts for solo instruments, the two groups being used in contrast—the former was called the concerto grosso, the latter the concertino.

In form and style the concerto is derived from the Italian vocal aria, the whole essence of which was the effective opposition of a solo voice against an instrumental background, and also the blending of the two opposing forces. Thus down to the present day the chief element in concerto style is the opposition of unequal groups of instruments, although the more

modern concertos are largely concerned with the exploitation of one solo instrument.

Two other essentially orchestral forms are the *overture* and the symphonic poem or tone poem. Since the nineteenth century the overture has served two distinct purposes: (*a*) as a detachable orchestral introduction to an opera, such as Wagner's overture *Tannhäuser*, or (*b*) as a concert piece, such as Beethoven's overture *Coriolan*. In form the overture usually follows the design of the first movement of a symphony.

The *symphonic poem* dates from the mid-nineteenth century when Liszt began to produce his series of symphonic poems. His conception of this new musical form was an extended and continuous composition following a sequence of literary ideas or emotional moods. These ideas or moods are suggested in the music by the transformations of the main theme which represents the main idea of the literary story.

There are other forms, such as the canon, nocturne, study, and many dance forms, all of which either follow or are derived from the six basic forms mentioned above. However, it must be mentioned that all chamber music roughly up to the time of Haydn and Mozart was written in the various dance forms; after that time sonata-form became the pre-eminent pattern. Thus a trio is nothing more than a sonata for three solo instruments, a quartet is a sonata for four, and so on.

The Piano

A few words must be said at this point about the piano. Due to its ability to reproduce harmony in its widest ranges as well as melody, the piano has remained the most popular of all instruments. Broadly speaking, every other instrument (except the organ and the harp) demand other instruments to provide an accompaniment, but not so the piano which can even act as a substitute for an orchestra.

Although the earliest piano came into existence at the beginning of the eighteenth century, it was not until the end of that century when its mechanism had been considerably improved that it began to supplant those earlier and unique keyboard instruments, the virginal, spinet, clavichord, and harpsichord. Unfortunately it is the common practice today to play the beautiful literature for these instruments—the works of such English composers as William Byrd, John Bull, and Orlando Gibbons; the French composers Couperin the Great and Rameau; and the Italian Domenico Scarlatti—on the modern piano.

The piano received its first great impetus from Beethoven who wrote, apart from a host of other music, thirty-two sonatas and five concertos for it, in which the capabilities of the instrument are exploited with real understanding. Schubert followed closely on Beethoven's heels. Then came Chopin and Schumann and later Brahms and Liszt who exploited the genius of the piano to its fullest extent. Not only were these composers fine pianists themselves, but they were surrounded by virtuoso players who established the piano as a popular solo instrument. Owing to the experiments in and advance of piano technique made by these composers and virtuosos the mechanism of the instrument was perfected in almost every detail during the nineteenth century;

indeed, the modern pianist has not only a magnificent, responsive instrument at his command, but a wealth of great music that equals in quantity and quality the finest achievements in any other branch of musical composition.

Style in Music

The perfect style in art is that which is most effectively adapted to all conditions and circumstances of its presentation. The most important conditions are those of material. Thus a work of art in stone demands a different style to another work fashioned out of, say, iron. In music the conditions of style are similar. In his excellent book *Style in Musical Art*, Sir Hubert Parry says: "the simplest parallel to the differences of material in plastic arts lies in the varieties of means by which music is to be performed and made appreciable to sense. All music which is worthy of the name must, in the nature of things written, be performed by instruments or voices; and they all have their particular idiosyncracies. Organs have their special aptitudes and their special inaptitudes; and the music which is written for them, if it is to attain any degree of artistic perfection, must be based upon a recognition of the fact. Violins have their special powers of expression and effect, and their special limitations: horns have theirs, and trombones theirs. Voices can do certain things that instruments cannot do. There is, as it were, a dialect appropriate to each instrument and each class of voice."

If there is a style for each individual instrument there is an even more marked and individual style between say the orchestra and the string quartet or chorus. The orchestra is capable of almost unlimited complexities of treatment and it offers a vast palette of finely graduated colours. There is no question about the fact that the orchestra is today the most popular medium for making music. The conductor and his orchestra have taken the place in public esteem of the old trick virtuoso, particularly the prima donna; which, musically speaking, is a very good thing.

The Orchestra

It has been claimed that the modern orchestra is one of the supreme triumphs of the human mind, comparable to the discovery of the wheel and the power of electricity. This is undoubtedly true, and therefore it is quite understandable why the orchestra with its infinite variety of expression and colour appeals to the imagination of the vast music-loving public.

The history of the development of the orchestra is an interesting subject. The first to realize the possibilities of massed instruments as an accompaniment to vocal music was Monteverdi, that great composer of opera and madrigals. Then came Bach and Handel, who did much to develop orchestral technique. But it was left to their successors to realize the possibilities of colour as a quality in itself, and therefore to treat instruments individually. The Brandenburg Concertos of Bach and the concerti grossi of Handel show that at that time there was no standard orchestra, and there was very little difference in the treatment of one instrument and another; strings, woodwind, and brass often playing exactly the same types of passage.

The founders of the modern

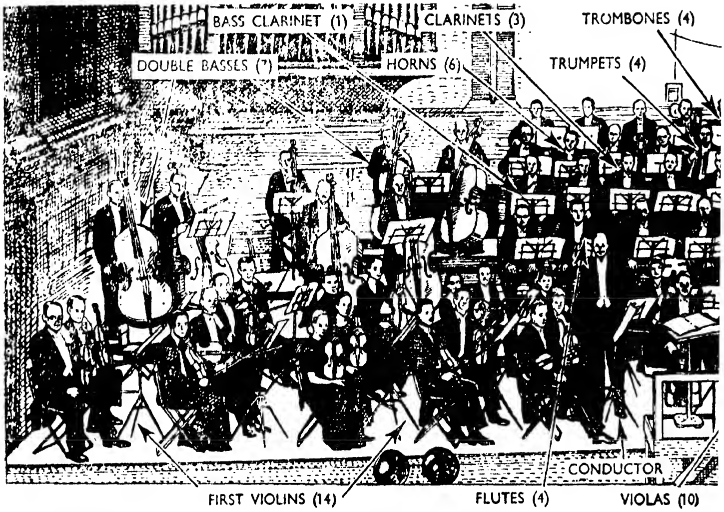


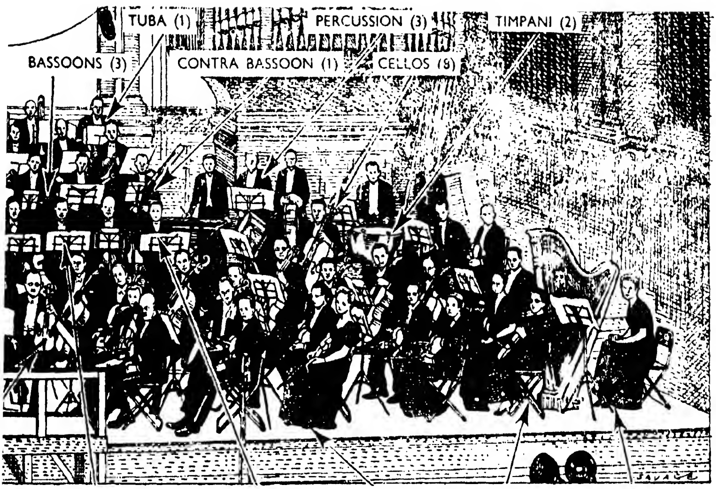
Fig. 2. *The British Broadcasting Corporation's Symphony Orchestra, with its conductor Sir Adrian Boult, showing the numbers and distribution of the*

orchestra, and of its most highly organized design, the symphony, were Haydn, Mozart, and their contemporaries. The strides made in the use of instrumental colour can be seen in the last symphonies of Haydn and Mozart.

With the nineteenth century came a vast improvement in the mechanism of brass and wind instruments, and Beethoven introduced many innovations that were to prepare the way for the exploitation of colour as a definite musical value by the great romantic composers from Berlioz to Strauss, Elgar and Debussy. The use of orchestral colour was now looked upon much in the same way as the palette of an artist, and both effects and contrasts of orchestration were used for pictorial and expressive ends. Thus composers came to think orchestrally, and both melody and harmony were conditioned by the orchestral conception.

With composers of today there has been a revolt against the romantic treatment of the orchestra, and composers such as Stravinsky, Respighi, and Prokofiev have exercised their ingenuity in exploiting the more piquant and grotesque characteristics of the instruments of the orchestra.

Few music-lovers realize that the great orchestras of today are a product of about the last seventy years. Towards the end of the eighteenth century when Haydn and Mozart were writing their finest symphonies, one of the best orchestras in Europe, the Concert Spirituel of Paris, consisted of fifty-three players: 10 first violins, 8 second violins, 4 violas, 10 'cellos, 4 double basses, 3 flutes, 2 oboes, 2 clarinets, 3 bassoons, 3 horns,



instruments. The drawing is based on a photograph taken at Bedford in 1945. Note: at this performance the orchestra was not at its full strength.

2 trumpets, 1 trombone, 1 drum. But the average orchestra of that period had considerably less: 6 first violins, 6 second violins, 3 violas, 3 'cellos, 2 double basses, and a very varied, often incomplete, number of wind players.

Even as late as 1850 when Liszt, who worked under fairly favourable conditions at Weimar, produced Wagner's *Lohengrin* for the first time he had an orchestra of 5 first violins, 6 second violins, 3 violas, 4 'cellos, 3 basses, 2 flutes, 2 oboes, 2 clarinets, 2 bassoons, 4 horns, 2 trumpets, 1 trombone, 1 tuba, and 1 kettledrum—a total of thirty-eight players for a rich and elaborately scored work like *Lohengrin!* Furthermore, one must remember that the technical standard of the average orchestral player during the eighteenth and nineteenth centuries was distinctly lower than the standards of our own time.

Compare the above figures with the B.B.C.'s Symphony Orchestra (see Fig. 2) in 1945: 16 first violins, 14 second violins, 12 violas, 10 'cellos, 7 double basses, 4 flutes, 4 oboes, 4 clarinets, 4 bassoons, 8 horns, 4 trumpets, 6 trombones, 1 tuba, 2 drums, 2 percussion, and 1 harp. Granted that the B.B.C. Symphony Orchestra is exceptional as the orchestra of the Concert Spirituel of Paris was in the last years of the eighteenth century, but the average number of players in English orchestras in 1939 was about eighty-five to ninety.

Chamber Music

There is no use denying the fact that chamber music has a very bad name, although a fair proportion of the greatest works of music

belong to that genre. Chamber music is often dismissed by the uninitiated (and by many of the half-initiated, too) as something highbrow, dull, and boring. It is dragged through the mire of the music-hall. Indeed, music-hall jokes about chamber music may be the last resource of the unresourceful comedian, but they are almost certain to get a laugh.

Fifty years ago chamber music had an infinitely larger public than it has now—and this despite the influence of the radio. The truth is that the glamour of the modern orchestra has been largely responsible. Listeners have become so accustomed to its rich variety of tone colour and its immense range of dynamics that the more delicate and intimate qualities of chamber music are too refined and too subtle for their ears.

Quality of Chamber Music

Now the orchestra has the power of making poor and indifferent music sound important, even exciting. Not so chamber music, of which the materials must always be of superfine quality. It has no gorgeous finery to cover up a poor idea or a weak piece of construction; in other words it does not possess the resources to make music sound better than it really is.

John Ireland, the distinguished English composer, once said on the radio that it follows that if a composer turns to chamber music as a medium of expression "he knows very well that only his best and most genuine musical ideas will be good enough to pass muster. Here it is the music itself that counts, not the way it is served up. This puts more of a responsibility on both the composer and the listener,

Fig. 3. *Christoph Willibald Gluck, German composer (1714-1787).*

but it also brings them into closer and more intimate contact. They are on more confidential terms, and can get to know each other better than when the machinery of a large orchestra stands between them."

We see, therefore, that in some ways chamber music may be considered one of the highest manifestations of the art of musical composition. Intimacy, indeed, is the quintessential quality of chamber music. The original meaning of the term was music composed to entertain a household—the household might be that of a royal personage or that of some less distinguished individual. During the nineteenth century chamber-music parties were almost as popular in Suburbia as bridge parties are today.

At the beginning of the nineteenth century Dr. Burney defined chamber music in an encyclopædia as "compositions for a small concert room, a small band and a small audience; opposed to music for the church, the theatre, or a public concert room." In the preface to

his famous *History of Music*, Burney speaks of chamber music as "cantatas, single songs, solos and trios, quartets, concertos, and symphonies of few parts." In fact, the early classical symphonies and string quartets differed little in style. Haydn's published Opus 1 was introduced in Paris in 1764 as "six symphonies or quartets for two violins, alto viola, and bass."

Opera

The history of opera goes back only as far as the sixteenth century, when a group of Italian amateur musicians experimented in musical declamation accompanied by a group of instruments. These experiments in combining music with drama were modelled on the lines of the old Greek drama, which, it is supposed, was sung to a kind of musical chant. As nobody knew how this chant was executed, for nothing had come down to posterity in the form of written chant, these early Italian composers of opera, or music drama, invented a kind of musical speech that approximated to chanting and which later became known as recitative.

The first complete opera written on these lines was Peri's *Euridice*, which was produced in Florence in 1600. The orchestral accompaniment consisted of viols, lutes, guitars, and a cembalo (a cembalo is a type of harpsichord). However, the first really great and original composer of opera was Monteverdi, who died in 1643. His *Orfeo*, which appeared a few years after *Euridice*, exploits dramatic effect to excellent purpose and the orchestra that he uses includes parts for strings, flutes and small organs. In this work and others Monteverdi introduced orchestral interludes between the acts which he called symphonies, and, generally speaking, laid the foundations of the modern orchestra.

Opera found its way into Germany, France, and England where Henry Purcell produced his masterpiece *Dido and Æneas*. French opera has had a distinguished career. It has never ascended to such heights as German and Italian opera at their best, but it achieves a happy medium between the symphonic seriousness of the one and the brilliant vocal virtuosity of the other. Furthermore, the claims of the music and the drama are fairly evenly balanced.

Dominance of Italian Opera

Italian opera always dominated the scene, as it has even up to the present day. By the middle of the eighteenth century Italian opera had reached a serious state of decadence. Not only was it bound down by conventions, that made it stereotyped and mechanical, but the music bore little or no connexion with what was happening on the stage. In short, Italian opera merely became a vehicle to show off the virtuosity of Italian singers. Unfortunately the Italian influence was so powerful that these conditions prevailed throughout Europe, particularly in Paris which was one of the great centres of opera at that time.

Then came the German composer Gluck (see Fig. 3) who decided, after having written a number of operas in the Italian style, to break away from convention and establish a new kind of opera that paid equal attention to dramatic and musical effect. In 1767 he produced his famous opera *Alceste*, in the preface to which he

attacked the abuses that had crept into Italian opera through what he called: "The mistaken vanity of singers and the unwise compliance of composers." He claimed that dramatic action was of first importance and that the music was there, not for its own sake, but to add to the emotional expression and to underline the dramatic situations. Furthermore, he gave great importance to the orchestral overture which he said ought to prepare the audience for the character and mood that was to be unfolded.

The Two Operatic Styles

The world of opera was broken up into two factions: composers who continued to work in the conventional Italian style and those who followed the lead of Gluck. As might have been expected most of the followers of Gluck were German composers. The composer who did more for German opera than any other was Mozart (see Fig. 4), who wrote operas such as *The Marriage of Figaro* in the Italian style as well as operas such as *The Magic Flute* in the German style. But Mozart had such an unerring sense of the stage and characterization, that even where he follows the Italian style he makes the drama almost as important as the music and avoids the more unnecessary and ludicrous conventions of the Italian style.

German opera came properly into its own during the nineteenth century, first with the romantic innovations of Weber, who was one of the first great masters of the modern orchestra, and with the even more important innovations of Wagner who, in his operas such as *Tristan and Isolde*, *The Mastersingers*, and *The Ring*, swept away all conventional ideas and created a new art form which he called "music-drama," and in which both the music and the drama are firmly interwoven in an extraordinarily realistic manner. No longer are there any set solos, duets, trios, and choruses, but everything is conceived as one dramatic whole, and what set numbers there may be arise naturally out of the action. More important still is the way that Wagner treats the orchestra, of which he was one of the greatest masters of all time. His treatment utilizes a highly ingenious system of what is called leitmotiv, that is to say, recognizable themes and motives associated with characters and dramatic ideas, which recur and are transformed throughout the work. Upon these the whole musical fabric is based.

In the meantime Italian opera was still being produced on conventional lines, but a number of extremely gifted composers, such as Rossini, Donizetti, and Bellini, infused fresh life into its set form by the sheer genius of their musical invention. In his *Barber of Seville*, Rossini created a masterpiece which is full of good theatre. These composers were followed by Verdi and Puccini who practically revolutionized Italian opera. While still retaining its essential vocal and melodic qualities Verdi in his last three operas, *Aïda*, *Otello*, and *Falstaff*, and Puccini in all his major operas, created a dramatic action that was as important as the accompanying music.

Operatic Presentation

The presentation of opera, whether good or bad, is perhaps the most difficult problem of all. Opera, in fact, is the most complex

of all art forms because it has to make the best of two worlds—music and drama. Furthermore, for its proper interpretation it requires first-rate singers who are also first-rate actors, to say nothing of highly imaginative production and presentation. No wonder there are so few operas that fulfil and receive all these demands and are therefore equally significant from the musical and dramatic points of view. Perhaps the most perfect examples of opera which fulfil these requirements are Mozart's *The Marriage of Figaro*; Rossini's *Barber of Seville*; Puccini's *Madame Butterfly*, *Gianni Schicchi*, and *The Cloak*; Wagner's *The Mastersingers*; and Verdi's *Falstaff*.

Even the most perfect of dramatic operas, such as those of Puccini, are apt to present some strange anomalies. After all you do not usually sing when you want to offer someone a drink, and you certainly never burst into song, however beautiful, when you are witnessing the death of your dearest friend or wanting to kill your worst enemy. But you do sing in your bath and very often when you are bubbling over with high spirits; which means that song is a natural expression of high spirits. The conclusion appears to be that comic opera is the most perfect form of opera. Further, there are few serious operas that can equal, as a perfect wedding of drama and music, Mozart's great work *The Marriage of Figaro* or Rossini's equally great *Barber of Seville*.

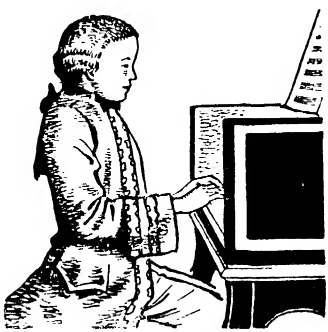


Fig. 4. *Wolfgang Mozart (1756-1791). The composer when a child.*

Four Vocal Musical Forms

Two vocal forms which are allied to opera are the oratorio and the cantata. The scale of the oratorio is often as elaborate as that of an opera with its set solos, concerted numbers, and choruses. Originally it was presented with dresses and scenery and therefore was very similar to an opera: in fact, the terms oratorio and opera were interchangeable as in the case of the early symphony and string quartet. The cantata is a short oratorio without scenery and dramatic action.

Two important purely vocal forms are the madrigal and the motet. The madrigal, which is written for unaccompanied voices, dates as far back as the end of the thirteenth century. It was brought to its highest state of development during the sixteenth and seventeenth centuries by three great schools of composers—the Flemish, the Italian, and the English. One of the most famous collections of English madrigals is known as The Triumphs of Oriana which consists of twenty-six madrigals written by different composers, praising the virtues of Queen Elizabeth. The madrigal is very free in style and is intended to be

sung by one voice to each part ranging from two to six, or even more, parts. It was not intended so much for public performance as for performance in the home, and therefore it is probably best described as a kind of vocal chamber music.

Whereas the madrigal was chiefly concerned with the setting of secular words, the motet, which is essentially church music, was concerned with the setting of Latin texts. In other words, it was the Catholic equivalent of the Protestant anthem and, like both the anthem and the madrigal, it was very free and contrapuntal in style.

German Song Composers

The solo song as a separate and highly organized musical form, as distinct from the folk-song and operatic aria, was brought to its highest state of development in Germany. Up to the nineteenth century German song had been firmly based on the *volkslied* (or folk-song), the influence of which persists even in the songs of present-day composers. The Italian style was also exploited by composers such as Haydn and Mozart. But one of the chief effects of the romantic movement in Germany was the development of a new form of romantic song or *lied* which was essentially German in spirit. Mozart had made some tentative efforts in this direction with that little masterpiece The Violet, a setting of Goethe's words, and one or two other songs. Beethoven followed rather more boldly in such songs as Adelaide and To My Absent Beloved. But it was left to Schubert to make song the perfect medium for romantic lyrical expression, and in his six hundred or more *lieder* he rose to heights that have never been surpassed.

From Schubert came a wonderful line of song composers, the greatest of whom were Schumann, Franz, Brahms, Wolf, and Strauss.

The chief development of the German *lied* after Schubert was, apart from greater resources of harmony, in the piano accompaniment. Schumann, for instance, in his Dichterliebe makes the accompaniment as important as the vocal line; the wonderfully impressive prologue and epilogue of this cycle sum up the whole drama of the story which the sixteen songs describe. In fact, it is wrong to allude to Schumann's "accompaniments"; they are too independent and poetically expressive to be called anything else but "parts."

Brahms was not a consistent romantic in his songs; that is to say, he did not always consider the words to be as important as the music. Like Schubert, he often followed the *volkslieder* tradition. His choice of words was by no means perfect; as H. C. Colles says: "He never set great poetry because it was great poetry, and he could be attracted by very poor poetry if it would make a song." But to what magnificent heights he could rise is shown in a host of songs, and nowhere more than in the superbly great Four Serious Songs. Hugo Wolf brought the German *lied* to its highest manifestation and made the words, the vocal line, and the piano parts arise out of one another.

French Song Composers

French song as a highly cultivated art form comparable to German *lieder* dates only from the early 'seventies when Duparc pro-

duced that masterpiece L'Invitation au Voyage. It was the first of those *Mélodies* that Fauré, Debussy, Ravel, and others have made the crowning achievements of French song. The *mélodie* and the *lied* can be compared only with regard to æsthetic achievement, for their style and feeling are as entirely different as the Latin race is different from the Teuton.

The real inspiration behind the French *mélodie* was the poetry of the Symbolists, of whom Verlaine was the most influential. The *raison d'être* of this new style of song was therefore literary rather than musical: one of the most characteristic features of the *mélodie* is that the rhythm and shape of the melodic line is often moulded by the inflections of the spoken word. Edward Lockspeiser has admirably summed up the *mélodie* as "an intimate union of word and song . . . less intense in emotional appeal, less picturesque perhaps than the corresponding union in the German *lied*, but more delicate and more poignant in expression." At their finest they "reveal that moving combination of sensuous charm and naïveté characteristic of the greatest French art."

British Song Composers

No country has ever equalled Britain for the quantity and quality of her poetry, which has flourished for an unbroken period of six centuries. On the other hand, there are few important countries up to the present century that have not surpassed Britain in musical achievement, excepting perhaps in one branch of composition, namely, song, which is, after all, the natural complement of poetry. Thus, the British enjoy one of the richest of folk-song traditions and a school of song-composers (Tudor and Jacobean) whose work, both religious and profane, occupies a foremost place in the history of music.

However, at that time music was an important part of everyday life, as it has never since been anywhere: to be able to sing or play an instrument, to read a part at sight, in madrigal or in consort of lutes or viols, to accompany on the spinet or the virginal, was as much a part of the ordinary person's equipment as walking or riding. These were not accomplishments the possession of which marked one out for special favour or attention: they were taken for granted.

After this Golden Age the Dark Age, as Sir Henry Hadow aptly calls it, set in, and for roughly one hundred and fifty years during the eighteenth and nineteenth centuries little or nothing was produced in any branch of music that could compare with what was being produced on the Continent. Then at the end of the nineteenth century and in the early years of the present century came, like manna from heaven, a wonderful revival of the English song which gathered momentum as each decade passed. Today Britain can show a school of song-composers headed by John Ireland, Sir Arnold Bax, Vaughan Williams, Peter Warlock, Roger Quilter, whose achievements at least equal what has been produced in Germany and France during the last quarter of a century or more.

The Changing Face of Music

As mentioned previously, music up to the sixteenth century was chiefly vocal and it was not until the succeeding centuries that instrumental music really came into its

own. Thus the music of Bach and Handel represents the parting of the ways. Whereas the choral music of the great composers of the fifteenth and sixteenth centuries is unaccompanied, we find that the choral music of Bach and Handel, which is still in the contrapuntal tradition, has instrumental accompaniment. Then came the period of the symphony which was developed and perfected by Haydn, Mozart, Beethoven, and their contemporaries.

The period from Bach up to the time of Beethoven's early manhood (roughly from the end of the seventeenth century to the end of the eighteenth century) is usually called the Classical Period. It is a period when beauty of form or design in music, particularly in the symphony and sonata, was the chief consideration of composers. When Beethoven came on the scene music had become very formalized. In fact, the chief characteristic of all the arts at the end of the eighteenth century was an excess of superficial decoration superimposed upon a set and stereotyped pattern that had become mechanical in its use. Not, of course, in the hands of a Mozart or Watteau, but in the hands of the second- and third-rate artists of that time.

The Romantic Movement

A violent reaction against this state of things started in Germany among a group of young poets and writers. It became known as the Romantic Movement, of which the influence was soon felt all over Europe, notably in France and England. Classical ideals were overthrown and artists set out first and foremost to arouse strong emotion by writing novels and poems and painting pictures that were based on picturesque and realistic subjects of an essentially romantic character. Anything that would appeal to the senses in the way of brilliant and gorgeous colour (whether in paint or descriptive writing) was, of course, utilized. The novels of Scott, the poems of Byron, and the paintings of Rossetti are typical examples.

All this happened at an important time in the history of music, a time when the mechanism of musical instruments was being rapidly improved and the development of harmony and of the technique of the orchestra was being considerably extended. The natural consequence was that musicians became deeply affected by the romantic movement in the sister-arts and began to apply some of its principles to music. Music must express deep emotion and depict romantic stories and situations, and design in the classical sense of the term was a secondary consideration—purely an adaptable means to an end. In these circumstances the whole gamut of the sensuous qualities of musical sound were used to intensify emotional and picturesque effects.

Romanticism in music started with Weber in Germany and Berlioz in France, continued by way of Schumann, Chopin, Liszt, reaching its zenith towards the end of the nineteenth century with the music-dramas of Wagner, the symphonies of Tchaikovsky, and the symphonic poems of Strauss.

Nationalism in Music

Nationalism in all its aspects was one of the most important by-products of the industrial revolution. So far as the art of music was

concerned, its most vital soil was to be found in those countries, like Russia, Scandinavia, and Bohemia, where the struggle for political freedom was the most vital and intense. At the same time the picturesque colour and rhythm of the more exotic kinds of folk-music appealed to the romantic musical mind. Composers endeavoured to imbue their music with a characteristic national style and idiom. "Listen attentively to all folk songs," said Schumann, "these are a treasure of lovely melodies and will teach you the character of different nations." Thus Smetana and Dvořák in Bohemia; Glinka, Rimsky-Korsakov, Borodin, and Mussorgsky in Russia; and Grieg (see Fig. 5) in Norway saturated themselves in the folk lore and folk songs of their respective countries and produced a national music which repudiated the German and Italian influences that had dominated the world of music for so long.

Musical Impressionism

Since the eighteenth century music has been considerably influenced by new ideals in literature and painting. We often hear the term impressionistic as applied to music. Impressionism started in painting. Although it was anticipated by the English artist Turner, the most vital part of the movement was essentially French. It first attracted attention in the 1860s, when Manet, Monet, Renoir, and their group took a stand against the pedantry of the academics by adopting an unheard-of freedom of technique and novel treatment of subject. Their æsthetic aim was to paint a subject as it appeared to the artist at a given moment. Thus

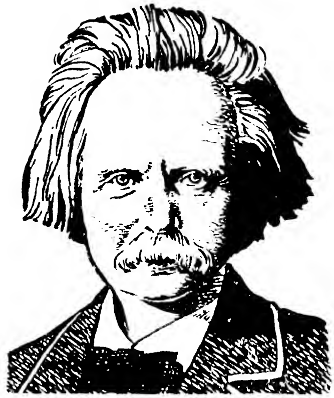


Fig. 5. *Edvard Hagerup Grieg, Norwegian composer (1843-1907).*

blurred and striking effects of light brought about by reflection or atmosphere play an important part in the Impressionists' conception: the ultimate appeal being sensual rather than intellectual.

The movement gradually became very powerful, and even influenced the outlook of contemporary poets and musicians. In fact, never before had the æsthetic ideals of the three arts been quite so closely associated. Painters exploited the possibilities of what they called colour harmonies and considered the most luminous degree of light as their principal theme. The Symbolist poets sought inspiration in music and endeavoured to make language produce the same kind of emotional feelings as they obtained from music. Mallarmé said that "to *name* an object is to sacrifice three-quarters of that enjoyment of the poem which comes from the pleasure of guessing the poet's intentions bit by bit. To suggest it —that is our dream."

The Impressionist movement in

music, although anticipated by other composers, centred round the work of Debussy. He was the most consistent in his use of impressionistic technique, but other great composers who came after him used it as their subject or fancy demanded—Ravel, Delius, Falla, for instance. The basis of Debussy's impressionistic technique is his highly specialized and individual harmonic idiom and his treatment of the instruments of the orchestra, which in terms of colour offers almost an exact parallel to the Impressionist painter's use of the palette. L'Après midi d'un Faune, the three Nocturnes, the three symphonic sketches La Mer, and the three orchestral Images are some of his most vivid and beautiful examples of impressionism.

Modern Music

The bitter animosity towards the music of our time on the part of a large section of the musical public is chiefly due to the use of what is conveniently called dissonance. There is only one true consonance —the octave. Every other interval is dissonant in varying degree—as Percy Scholes puts it: "they have some degree of harshness owing to the existence of a more or less perceptible throb or beat set up by discrepancy in their vibration numbers. The degree of dissonance bearable differs according as the human ear is more or less accustomed to it."

What so many listeners do not seem to realize is that the history of music shows a continual process of rejection and acceptance of dissonance. In Mosco Carner's book *A Study of Twentieth-Century Harmony*, which can be recommended to students as a first-rate guide to this interesting and important subject, attention is drawn to the fact that in the fourteenth century Jean de Muris complained in his *Ars Contrapunti* of the use of new dissonances; at the beginning of the seventeenth century Monteverdi shocked his contemporaries with his harmonic audacities; Beethoven was criticized for the harshness and stridency of his harmonies in the Eroica Symphony; Wagner's harmonic innovations were regarded as scandalous; and Strauss's *Elektra* was responsible for the introduction of the term cacophony.

Dr. Carner states a fundamental truth when he says that "music without dissonances is monotonous and æsthetically unsatisfactory." What gives life to music is movement, and musical movement is born not only of rhythmic energy but also of the interplay of dissonance (tension) and its resolution, the consonance (relaxation). Just as our life processes are dependent on the right proportion between tension and relaxation, so is musical movement largely dependent on the right ratio between dissonance and consonance.

What is the right ratio? The history of music shows that each generation decides that its own ratio is the right one. Thus the truth is that there is no absolute standard of consonance and dissonance. They are relative terms. Unsophisticated listeners and hidebound academic musicians are too apt to consider that the period which roughly extended from Bach to Brahms and from which the greater part of our present-day popular repertoire is drawn represents the right ratio. In other words, no really great, pleasing, and expressive music existed before

Bach or exists after Brahms. This is, of course, nonsense. Most musicians agree only to the fact that during the twentieth century some composers have experimented with dissonance to an unprecedented extent with the result that many composers have lost touch with their public.

Amidst all this experiment and iconoclasm there are numerous composers—perhaps more in Britain than anywhere else—who, working quietly, have not swallowed whole all the new devices and theories invented by their more adventurous and dissatisfied contemporaries. These composers have absorbed merely those devices and harmonic innovations that have appealed to them, and therefore they have produced music that has not lost touch with their public.

The study of the history of musical appreciation shows a continual struggle of the human ear to get used to new and unfamiliar sounds, particularly new harmony (chords). If you are going to swear allegiance to the music of the past and refuse to spend any time on the music of the present, then music will eventually become an archaic and moribund art.

In no other art is conservatism and prejudice in appreciation so rampant. This idolizing of Bach, Beethoven, and Brahms as the only composers worthy of attention is wrong and anti-musical. If you are literary-minded you do not say Shakespeare, Milton, Goethe, and Balzac are unequalled by modern writers, therefore you have no time for the latter. If your mind is properly alive you re-read *Hamlet* and *The Pickwick Papers*, go to see a play of Galsworthy or Shaw, and get from your circulating library the latest books of Aldous Huxley and Eric Linklater.

When it comes to music, why not show the same intellectual and emotional curiosity and broad-mindedness? Accept Palestrina, Bach, Beethoven, Mozart, Chopin, Wagner, Debussy, Sibelius, Walton, and Poulenc in your stride. After a fair and reasonable trial of these composers reject what you consider to be bad and uninteresting and concentrate on what you consider to be good and interesting. But never close your mind to new ideas and experiences.

Musical Masterpieces

It has been possible here to make only a selection, more or less arbitrarily owing to the limits of space, of great masterpieces of music that have won international popularity. The works that have been chosen are those that have a literary or historical background which throws some light on the meaning of the music. Some readers may wonder why it has not been possible to include equally well-known and popular works, such as Tchaikovsky's Piano Concerto No. 1 in B flat minor and certain symphonies of Haydn and Mozart. The reason is that there is no story to these works and the music can only be explained in terms of musical values. That, of course, really applies to all music. As mentioned, the final value of a piece of music is its musical value, which remains unaffected by its literary background.

Beethoven's Heroic Symphony

Soon after the completion of the Second Symphony, Beethoven informed one of his friends that he was not satisfied with his music up

to that time and that "from today I mean to take a new road." In the following year, 1803, he produced his Symphony No. 3 in E flat, which had been conceived on strikingly original lines, both in form and idiom. The dramatic intensity and spaciousness, and the fine sweep of its four movements, set a new note in symphonic writing that appeared revolutionary at the time. Although the movements are very long they have been constructed with a superb sense of organic growth, particularly the slow movement, which is the greatest of all funeral marches. Again the scherzo, with its almost aggressive humour, and the finale, in the form of a set of profound variations, were certainly unique.

The music, particularly of the first two movements, is intentionally heroic in character, for the work as a whole was inspired by Beethoven's ideal hero, Napoleon. The original manuscript bore the inscription "Bonaparte." On May 18, 1804, Napoleon assumed the title of Emperor, and when Beethoven heard the news he tore up the title page of his new symphony and said: "After all, then, he is nothing but an ordinary mortal! He will trample all the rights of men underfoot to indulge his ambition, and become a greater tyrant than anyone!" Later Beethoven described the symphony as a "Heroic Symphony to celebrate the memory of a great man."

A great deal of nonsense has been talked about the programmatic basis of the Eroica Symphony, as if Beethoven had intended to write a biography of Napoleon in the form of a symphony. Sir Donald Tovey aptly sums up the matter as follows: "Beethoven does not think a symphony a reasonable vehicle for a chronological biography of Napoleon, but he does think it the best possible way of expressing his feelings about heroes and hero-worship."

Berlioz's Fantastic Symphony

Berlioz's best known and most popular work is undoubtedly the Fantastic Symphony. The composition was completed in 1830, but later drastically revised. This symphony was written under the emotional stress of his love for Harriet Smithson, the actress, who at first could not be bothered with him.

The Fantastic Symphony is concerned with the story of a young musician (Berlioz) of an unhealthily sensitive nature and a very vivid imagination. He has poisoned himself with opium in a fit of lovesick despair, but the dose is too weak to do more than put him to sleep. His dreams take the form of musical imagery and even his beloved (Harriet Smithson) becomes a melody—the recurring theme that runs through the work.

In the first movement the young musician thinks of his varied and conflicting emotional states before he met his beloved. He recollects the ardent love which she suddenly inspired in him, his raging jealousies, the reawakening love, and then religious consolation. The second movement depicts a ballroom where in the whirl of a brilliant function he finds her. The third movement describes a summer evening in the country. Two shepherds play on their pipes a tune used by the Swiss to call their flocks together. The pastoral scenes and sounds give the young musician the repose he needs, but

suddenly his beloved appears and he is filled with forebodings and uncertainties. The shepherds resume their tune, the sun sets, there is distant thunder, the young musician is lonely . . . silence.

In the fourth movement the young musician dreams that he has murdered his beloved and is being led to the scaffold. A last thought of his love comes to him as the guillotine descends. The fifth movement, which is called The Witches' Sabbath, describes his presence at a hideous witches' orgy. The beloved melody returns, but this time transfigured into a vulgar, grotesque dance. She has become a witch and she joins in the orgy. Bells toll for the dead. The Dies Irae is burlesqued and followed by the witches' dance. Finally the climax is reached with the Dies Irae being combined with the dance.

This fantastic story may add a certain interest to the music, but it is not necessary for an understanding of the symphony, which is well able to stand on its own as a piece of abstract music. Berlioz himself said that he hoped that the music would be listened to on its own merits irrespective of any dramatic aid.

The first thing that strikes one about the Fantastic Symphony is the incredible skill and subtlety of the orchestration, which for the first time in the history of music becomes an integral part of the actual musical thought and texture. When one considers that this work was written only three years after Beethoven died, there can be no doubt that Berlioz was one of the most original of all composers. Whatever may be said about Berlioz's limited harmonic sense and lack of melodic invention, the Fantastic Symphony still remains a masterpiece in the effective and imaginative use of rhythm, dynamics, and orchestral sonorities—a masterpiece that has rarely been equalled for these qualities.

Schubert's Unfinished Symphony

Schubert's musical development is a curious one. Almost from the beginning he appeared to realize the emotional and descriptive potentialities of music: a fact to which many of his early songs, such as Gretchen at the Spinning Wheel and The Erlking, bear striking testimony. But it was not until 1822, when he was twenty-five years of age, that Schubert began to apply a romantic technique to his instrumental music. No doubt illness, poverty, and a generally wider experience of life made him more introspective, with the result that his own emotional moods provided a similar creative stimulus to that which he had received before from reading poetry. The effect of his mental outlook upon some of his instrumental works is decidedly marked, two notable examples being the unfinished Symphony No. 8 in B minor and the String Quartet in G, Op. 161.

The six symphonies which preceded the B minor (No. 7 in C was written after No. 8) are essentially classical in both technique and spirit and the difference in style between the No. 5 in B flat, which is by far the finest of this group, and the No. 8 in B minor is almost as remarkable as that between Beethoven's second and third symphonies. While the first six symphonies were composed primarily for amateur performance, there is little doubt that Schubert intended a better fate for the B minor,

the scheme of dynamics alone would put the work beyond the average capacity of amateurs of that day.

Most biographers of Schubert continue to state that the B minor Symphony was written for the town of Graz in gratitude for his being elected an honorary member of the Styrian Musical Society. In his letter of acknowledgement to the Society, dated September 20, 1823, Schubert says: "May my devotion to the art of music succeed in making me worthy one day of this distinction. In order to express my liveliest thanks in music as well, I will make so bold as to present your honoured society at the earliest possible date with the score of one of my symphonies." Nearly a year later, after he had been sharply reminded by his father of his remission, Schubert sent the manuscript of the first two movements of the Symphony in B minor, which he had written (the original manuscript is headed with the date October 22, 1822) at least three months before he could have had any indication of being made a member of the Society. Having cast the work aside for so long, and having obviously lost interest in it, Schubert had no idea that he had left a masterpiece unfinished. All that concerned him for the moment was the fulfilment of his promise with the least amount of trouble, for his mind was now absorbed with other things. At least so far as the present writer is concerned, this would seem to be the most obvious explanation.

That the symphony was not suitable for amateur performance, nor yet properly completed, possibly provides the explanation of the fact that it was never produced by the Styrian Musical Society. Certainly, the director, Anselm Huttenbrenner, was fully aware of its value. In 1861, his brother Josef, writing about Anselm's collection of musical autographs, stated that "He possesses a treasure in Schubert's B minor Symphony, which we consider the equal to the great Symphony in C, his instrumental swan-song, and to any by Beethoven. Only it was not finished."

Eventually the original manuscript of the first two movements and sketches of the scherzo and trio were bequeathed by a Viennese collector to the Society of the Friends of Music. Since its first performance by this society in 1865, and its production in London at the Crystal Palace two years later, it has become the most popular of all symphonies. No doubt one of the chief reasons of its great appeal to musician and non-musician alike is its simplicity and beauty of musical means to attain grandeur of dramatic effect.

Tchaikovsky's Pathetic Symphony

The title of Tchaikovsky's Pathetic Symphony, which was written during the first half of 1893, was given it after its first performance. It was composed during a period of great mental tranquillity on the part of Tchaikovsky. In his brother's words, it was "an act of exorcism whereby he cast out all the dark spirits that had possessed him in the preceding years." Tchaikovsky never published a programme to the music, but he allowed it to be known that he intended to express certain personal emotions in the music of the Pathetic Symphony which he was unable to put into words.

In a letter to a friend, dated

February 23, 1893, Tchaikovsky said: "On the way to Paris last December, the idea for a new symphony came to me, this time a symphony with a programme, but a programme that will remain an enigma to all. Let them guess for themselves; the symphony will be called merely Programmatic Symphony. But the programme is indeed permeated with subjectiveness, so much so that not once but often, while composing it in my mind during my journey, I shed tears. As soon as I got home I began to write out the sketches, and it went so quickly and eagerly that in less than four days the first movement was done and all the rest clearly outlined in my head. Half of the third movement is ready. Its form will contain much that is new; for instance, the finale will not be a noisy *allegro*, but on the contrary, a quite long *adagio*."

In August, 1937, however, Gerald Abraham, the well-known authority on Russian music, informed English music-lovers for the first time that among Tchaikovsky's papers in his old home at Klin a sheaf of music-paper was recently discovered with the following notes scribbled in pencil: "The ultimate essence of the plan of the symphony is LIFE. First part—all impulsive passion, confidence, thirst for activity. Must be short. (Finale DEATH—result of collapse.) Second part love; third disappointments; fourth ends dying away (also short)." As Mr. Abraham points out, this rough draft does not quite agree with the final version of the symphony, "but we can hardly doubt that it is the embryonic plan of it and that this is the solution of the enigma."

In his biography of his brother,

Fig. 6. *Richard Wagner, German composer (1813-1883).*

Modest Tchaikovsky tells us that on the morning after the first performance of the symphony he suggested to Tchaikovsky that it should be called the Tragic Symphony. "I left the room before Peter had come to a decision. Suddenly the title Pathetic occurred to me. I went back into the room—I remember it all as clearly as if it happened yesterday—and told Peter of my idea. 'Splendid, Modi, bravo. *Pathetic*,' he cried. And in my presence he wrote down the title it has borne ever since."

Wagner's Opera "Tannhäuser"

Wagner (see Fig. 6) had been familiar from youth with the two subjects that he combined in his opera *Tannhäuser*. He had read of the knight Tannhäuser and his seduction by Venus in Tieck's poem, and E. T. A. Hoffmann's novel *Der Sangerkrieg* had interested him in the story of the song contest of the Minnesingers at Wartburg (to

which his version of the song contest of the Mastersingers at Nuremberg was originally intended as a comic counterpart). Then early in the 1840s, the old *Volksbuch* of Tannhäuser fell into his hands, which reawakened his enthusiasm for the figure of the hero, and suggested to him the combination of the two stories.

The first sketches were made in 1842; the libretto was finished the following year and the score in April, 1845. The first performance was given at Dresden on October 19 of that year.

Wagner wrote *Tannhäuser* in a veritable turmoil of emötion. He was so carried away with the idea that he even feared that sudden death might cheat him of his goal. He longed "for the highest form of love" as an antidote to his "loathing of the modern world." If the great love duet in *Tristan* is the apotheosis of spiritual love there is no doubt that the Venusberg music is its counterpart of physical love. No music could be more voluptuous: melody, harmony, rhythm, and orchestration appear to be calculated to appeal primarily to the senses, although, of course, every detail is worked out with the hand of a master craftsman.

The story of *Tannhäuser* takes place around the Wartburg, where during the thirteenth century the Landgraves of the Thuringian Valley ruled. Near the castle at which music and poetry were cultivated to a considerable extent was the Venusberg, in the interior of which lived Venus, the Goddess of Love, and her court of nymphs, naiads, and sirens. Her chief amusement was to entice into her palace the knights and minnesingers of the Wartburg. One of these knights, Tannhäuser, who has been under the spell of her beauty, now longs to return to the world. Venus uses all her strategies to keep Tannhäuser, but at last he invokes the name of the Virgin at the sound of which Venus disappears with a cry, her palace is obliterated, and the knight Tannhäuser finds himself in the sunshine prostrate before a cross in the valley below the Wartburg.

The Overture to "Tannhäuser"

The overture, a remarkable piece of colourful tone painting, symbolizes the conflict between good and evil which is the essence of the drama. First we hear the music of the Pilgrims' Chorus, here played by clarinets, bassoons, and horns. It soon rises to a climax, at the height of which the violins enter with a fiery accompaniment figure said to represent "the pulse of life." Gradually it dies away and the Chorus with it.

The foregoing is a sort of slow introduction. The main part of the overture follows: a vivid picture of the sensual joys of the Venusberg. First, a wild viola figure, unleashing *tremolo* violins and riotous wind-passages, then Tannhäuser's virile, rapturous song to Venus. Later Venus's own seductive voice is heard (here represented by a solo clarinet), but the bacchanal is soon resumed (Tannhäuser's song with it). At its height it breaks into the fiery, pulsating violin figure of the introduction. Against it the Pilgrims' Chorus theme is heard again, first quietly in its original soft wind colours, later on trumpets and trombones *fortissimo*, and the overture reaches its conclusion in a triumphant blaze of sound.

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Figures in italics refer to illustrations

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